Management of the California State Water Project - Appendix E

2001 Water Operations in the Sacramento-San Joaquin Delta

October 2004 *Bulletin 132-02*

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State of California

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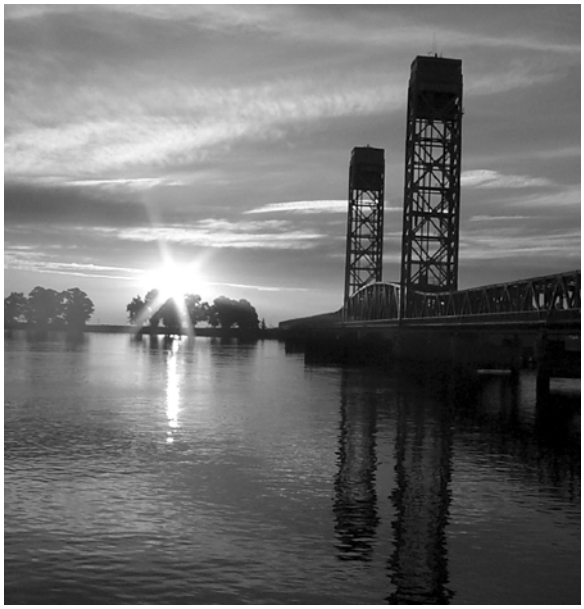

Cover: *The Rio Vista Bridge crossing the historic Sacramento River is one of many drawbridges designed by Joseph Strauss, the architect of the Golden Gate Bridge*

Cover photograph courtesy of Angelo Garcia, Jr.
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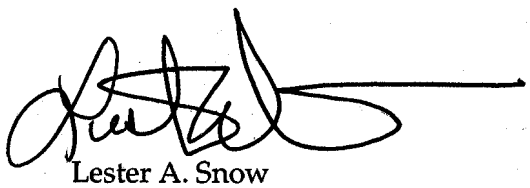
FOREWORD

This is the twenty-seventh edition of Appendix E, Bulletin 132, *Water Operations in the Sacramento-San Joaquin Delta*, an annual publication written for the State Water Project contractors, resource agencies, the State Water Resources Control Board, and other regulatory agencies. Appendix E documents SWP operations in the Sacramento-San Joaquin Delta, in addition to reporting on Delta water quality. SWP operations are modified to meet water quality standards and flow requirements, as well as environmental and other operational constraints.

The Sacramento-San Joaquin Delta has often been called the focal point of water resources development in California's Central Valley. The Delta is the collection point for State Water Project water delivery to the San Francisco Bay Area, the San Joaquin Valley, and Southern California. Thus Appendix E is designed to document significant Delta events as well as to review overall performance of SWP Delta operations.

This report is based on the 2001 water year (October 1, 2000, through September 30, 2001), which was classified as *dry* for all beneficial uses under criteria set forth in the SWRCB's Decision 1641.



Lester A. Snow
Director

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California Water Commission

The California Water Commission serves as a policy advisory body to the Director of Water Resources on all California water resources matters. The citizen commission provides a water resources forum for the people of the State, acts as a liaison between the legislative and executive branches of State Government, and coordinates federal, State, and local water resources efforts.

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Acronyms and Abbreviations

af	acre-feet
CALFED	State and federal resource agency program coordinating Bay-Delta management activity
cfs	cubic feet per second
CL	chloride concentration
COA	Coordinated Operation Agreement
CVP	Central Valley Project
CVPIA	Central Valley Project Improvement Act (PL 102-575, Title 34)
D-1379	SWRCB Water Right Decision 1379
D-1422	SWRCB Water Right Decision 1422
D-1485	SWRCB Water Right Decision 1485
D-1630	SWRCB Water Right Decision 1630
D-1641	SWRCB Water Right Decision 1641
DCC	Delta Cross Channel
Delta	Sacramento-San Joaquin Delta
DFG	Department of Fish and Game
DO	dissolved oxygen
EC	electrical conductivity (also referred to as specific conductance)
ESA	California Endangered Species Act
EWA	Environmental Water Account
FERC	Federal Energy Regulatory Commission
FESA	federal Endangered Species Act
FRSA	Feather River Service Area
IEP	Interagency Ecological Program
ISDP	Interim South Delta Program
JPE	Juvenile Population Estimate
maf	million acre-feet
NBA	North Bay Aqueduct
NDOI	Net Delta Outflow Index
NOAA Fisheries	National Marine Fisheries Service
PMI	Previous month's Eight River Index
RTM	real-time monitoring
SDIP	South Delta Improvement Program
SJRA	San Joaquin River Agreement
SRI	Sacramento River Index
SWP	State Water Project
SWRCB	State Water Resources Control Board
the Bureau	Bureau of Reclamation
taf	thousand acre-feet
USFWS	U.S. Fish and Wildlife Service
VAMP	Vernalis Adaptive Management Plan
X2	location of 2 ppt. isohaline

1. Summary

Water Supply Conditions

Water year 2001 (October 1, 2000, through September 30, 2001) started out with an extremely wet month, but the water year ended with statewide precipitation at 75 percent of average. The water year was classified as *dry* under State Water Resource Control Board criteria.

Water Supply Schedules - Actual Deliveries

The State Water Project delivered 3.22 maf of water to 27 long-term contractors and 17 other agencies during 2001. SWP deliveries included 1,615,934 acre-feet of approved Table A water; 43,182 acre-feet of Article 21 water; 253 acre-feet of unscheduled water; 74,992 acre-feet of Article 54 flexible storage withdrawal; 2,929 acre-feet of SWP water for recreation and fish and wildlife; and 1,556,491 acre-feet of water delivered to satisfy water rights settlement agreements and agreements with SWP contractors and other agencies, including the Bureau of Reclamation.

In December 2000, SWP contractors were scheduled to receive 40 percent of their approved Table A requests (1.65 maf) for water year 2001. Dry conditions caused the Department to decrease the approved Table A amount to 20 percent on January 31, 2001. The approved Table A amount was increased twice in March and twice in May before finally being increased to 39 percent (1.61 maf) on August 16, 2001.

State Water Project Operations

During 2001, the SWP operated under SWRCB's Decision 1641. D-1641 was adopted in December 1999, including Phases 1-7 of the Decision. Phase 8 was left for later consideration and involves the assignment of responsibility among the Sacramento River Basin water rights holders for meeting the objectives of the 1995 Bay-Delta Water Quality Control Plan. During 2000, the resumption of Phase 8 hearings was postponed until 2001.

On April 26, 2001, SWRCB adopted WR 2001-5. This order stays the resumption of Phase 8 of the Bay-Delta Water Rights Hearing for 18 months. The order followed negotiations and formal agreement amongst the Sacramento River Basin water rights holders. The order automatically dismisses Phase 8 at the end of the 18 months, unless SWRCB receives notice from the Department or the Bureau, requesting resumption of Phase 8.

The 1995 Bay-Delta Water Quality Control Plan resulted from the establishment of the 1994 State-federal Bay/Delta Accord. The Accord sprang out of the need for a coordinated and comprehensive ecosystem approach to management of the Bay-Delta and was designed to balance proposed SWRCB water quality standards and federal Endangered Species Act operational criteria, with the need to provide water supply reliability.

The CALFED Operations Group provides guidance to SWP and CVP for the protection of targeted fisheries. It provided this guidance based

upon data gathered from real-time fisheries monitoring to effectively implement immediate decisions on export timing, Delta Cross Channel Gate operations, and temporary barrier placements. The institutional framework guiding SWP Delta operations during 2001 can be found in Chapter 4, Table 4-5.

Lake Oroville and Feather River Operations

Storage at Lake Oroville was 1.92 maf (54 percent capacity) at the beginning of water year 2001. Inflow into the reservoir during the water year totaled 1.89 maf (41 percent of average). Lake Oroville reached its storage peak on May 6, 2001, at 2,203,836 af (62 percent of capacity). Minimum storage occurred on September 29, 2001, with Lake Oroville at 42 percent of capacity (1,483,999 af) and the water year ended on September 30, 2001, with carryover storage of 1.49 maf.

Feather River Service Area contractors took water deliveries every month of 2001 except February and March, for a total of about 1.1 maf, and returned a calculated 0.14 maf as agricultural runoff.

Releases from the Oroville-Thermalito Complex augment the flow of both the Feather and Sacramento Rivers while retention of storage reduces downstream river flow. Mean monthly river flow was augmented during January and from May through November, with the highest augmentation occurring during June through August. River flow was reduced during December and from February through April, with the greatest monthly reduction occurring in March.

Delta Operations

Operation of the SWP affects the Sacramento-San Joaquin Delta in many ways: high winter and spring inflows are reduced; outflows can be decreased to provide contracted water deliveries or off-stream storage; Sacramento River flow and Delta outflow can be augmented, and the natural Delta circulation and outflow patterns can be altered.

Aerial view of O'Neill Forebay

During 2001, Delta conditions, as defined by the 1986 Coordinated Operating Agreement, fluctuated from balanced to excess conditions many times throughout 2001. The year began under excess conditions and ended under balanced conditions, accumulating 118 excess condition days by year's end.

The Delta Cross Channel gates are operated in accordance with D-1641, which lists closure periods from November 1 through June 15. During the balance of the year, the gates typically remain open, though they may be closed for short periods in response to high Sacramento River flows, Delta water quality concerns and fishery protection, as well as hydrodynamic and fishery experiments.

During 2001, the DCC gates were open for 192 days. The gates were open during the first half of January with Sacramento River flows remaining below 25,000 cfs. The gates were subsequently closed from January 14 through June 14, with the exception of three 2-day open periods during late January, late May, and early June for recreational boat traffic. From June 15 through November 21, the gates were open, except for the night and tidal operation that occurred during an experimental period that ran during August, September, and October. The gates were closed during late November for the protection of juvenile salmon and closed again December 4 as precipitation brought Sacramento River flows above 20,000 cfs.

Delta Outflow

D-1641 sets flow standards for the San Joaquin River at Vernalis, Sacramento River at Rio Vista, and Delta Outflow using the Net Delta Outflow Index.

San Joaquin River at Vernalis flow standards are in force from February through June and vary by water year type and the location of the geographic isohaline, whether east or west of Chipps Island. All Vernalis flow requirements were met in 2001.

Flow standards at Rio Vista on the Sacramento River are set as minimum monthly means from September through December and become less stringent during critical water years. In October 2001, Rio Vista flow reached its lowest monthly average of the year at 4,242 cfs, meeting the monthly minimum of 4,000 cfs. All Rio Vista flow standards were met during 2001.

D-1641 contains Delta outflow standards set as minimum monthly average of NDOI for January and July through December. All NDOI standards were met in 2001. The year's highest monthly average NDOI occurred in March with 23,152 cfs and the lowest monthly average NDOI occurred in August with 3,467 cfs.

Delta Exports

D-1641 includes a standard for how much water can be diverted at Tracy and Banks Pumping Plants relative to Delta inflow. This standard can vary between 35 and 45 percent of Delta inflow for February through June, depending upon the Eight River Index, and is set at 65 percent from July through January. During January 2001, the percent of inflow diverted averaged 36 percent. During February, the standard was increased from 35 percent to 45 percent because the January Eight River Index was less than 1.0 maf. Exports averaged 37 percent of Delta inflow for the month and concern over Delta smelt salvage and winter-run salmon loss resulted in numerous export curtailments.

From March through June, exports averaged 20 percent, far less than the 35 percent standard. During this period, exports were affected by fishery concerns, VAMP, X2 complications, a California Aqueduct leak, and low water levels in the south Delta.

D-1641 allows 65 percent of Delta inflow during July through December and exports averaged 46 percent for this period in 2001. Exports were restricted in August to ensure compliance with the Jersey Point EC standard and to avoid exceeding the chloride standard at Contra Costa Canal. The Contra Costa Canal chloride standard was exceeded three times in October as water quality concerns continued to hamper exports during October and November.

Operations under Winter-run Salmon and Delta Smelt Biological Opinions

The amended Winter-run Chinook Salmon Biological Opinion includes the concept of a warning (*yellow light condition*) when the combined loss at Tracy and Banks Pumping Plants reaches 1 percent of the (previous year's) 2000 estimated out-migrating juvenile winter-run salmon population (3,702 smolts). The yellow light condition calls for a voluntary adjustment in operations in an effort to decrease winter-run salmon loss. A loss level of 2 percent (7,404 smolts) triggers what is called a *red light condition* and requires formal consultation with the Winter-run Chinook Salmon Monitoring Group.

On February 22, 2001, the winter-run salmon yellow light condition was exceeded and the Department began consultation with National Marine Fisheries Service (NOAA Fisheries) and U.S. Fish and Wildlife Service. Exports were reduced from February 16 through 24 in an effort to stem the increasing loss. High winter-run salmon loss continued into March, the red light condition was exceeded on March 5, and consultation with NOAA Fisheries and USFWS was reinitiated. Environmental Water Account assets for the protection of winter-run salmon were exhausted by March 11. By May 31, 2001, the combined loss of winter-run salmon totaled 20,008 smolts.

The amended Delta Smelt Biological Opinion limits the combined incidental take of Delta smelt at the pumps of the SWP and CVP. The combined yellow light limit of 400 Delta smelt is imposed year-round and is based on a 14-day running average of daily salvage. A red light level was also established limiting the cumulative combined salvage. The red light numerical salvage limit varies by month and water year type.

Delta smelt salvage spiked briefly in late February but an export curtailment helped the 14-day running average of salvage remain below the 400 fish yellow light level until late May. In late May, exports were held at the VAMP levels (1,500 cfs combined) as a result of increasing Delta smelt salvage, but the yellow light level was exceeded on May 21 nevertheless. Salvage declined and exports were allowed to gradually increase to a combined maximum of 4,000 cfs by June 5. Unlike previous years, the combined Delta salvage never rose to the red light level during 2001.

Sacramento Splittail Salvage

USFWS listed the Sacramento Splittail as threatened under the federal Endangered Species Act on February 8, 1999. In 2000, a Federal District Court judge found that the USFWS decision to list the splittail was not reached in accordance with the law and remanded the decision to USFWS for further analysis and review. During 2001, USFWS opened the ESA comment period three times. A final rule is still pending. Though no formal take limits for splittail were in place during 2001, the SWP and CVP fish salvage facilities have continued to keep an accurate count of the combined splittail salvage. The total combined splittail salvage for 2001 was 7,009 fish.

Environmental Water Account

The Environmental Water Account is a cooperative water management program made up of five State and federal agencies. EWA was mandated in the CALFED Record of Decision signed on August 28, 2000. It was designed to help protect endangered and/or threatened fish species of the Bay-Delta estuary through environmentally beneficial changes in the operations of SWP and CVP, while ensuring the ability of the projects to continue water delivery for agricultural and urban uses. EWA does not incur any uncompensated water cost to the projects' water users. Water year 2001, which began on October 1, 2000, was the first year of operation for EWA.

North Bay Aqueduct Operations

The North Bay Aqueduct conveys Delta water pumped at Barker Slough in the north Delta to contractors in Napa and Solano Counties. Deliveries to the NBA totaled 43,931 af during 2001, about 1 percent of total SWP deliveries.

In 2001, NBA conveyed a total of 34,586 af for Solano County Water Agency—of which 17,756 afs were approved Table A supply. Napa County received a total of 9,345 af—of which 4,293 af were approved Table A supply. Of the total 43,931 af delivered to both Napa and Solano, 3,300 af of water was delivered under Article 21 and 15,756 af was non-SWP water.

Delta Water Management

The Department's South Delta Improvements Program, formerly the Interim South Delta Program, began in 1991. During most years, SDIP installs south Delta temporary barriers at locations on Middle River, Old River at Tracy, at the Head of Old River, and on Grant Line Canal. All but one of these barriers are designed to improve water levels and to improve circulation for agricultural users in the south Delta.

The Head of Old River barrier prevents San Joaquin River flow from entering Old River and flowing toward SWP and CVP export facilities. The additional flow in the San Joaquin River helps guide juvenile salmon to the ocean in the spring and improves the dissolved oxygen concentration for salmon migrating upstream to spawn in the fall.

During spring 2001, the Old River at Head barrier was installed by April 26 and was removed by May 30. In the fall, it was installed by October 6 and its removal completed on December 2, 2001.

The Middle River barrier was installed on April 23 and removal was completed on November 17, 2001. The Old River barrier near Tracy is installed on Old River, one-half mile east of Tracy Pumping Plant. It was installed on April 26 and its removal completed on November 26, 2001.

The Department began the annual installation of the Grant Line Canal barrier east of Tracy Boulevard Bridge in 1996. The Grant Line Canal barrier was installed on June 1 and removal of the barrier was completed November 18, 2001.

Delta Water Quality Standards

Delta water quality is primarily regulated by salinity standards and objectives measured as electrical conductivity or chloride concentration. These measurements reflect the impact of seawater intrusion and agricultural drainage as affected by tributary inflows, reservoir releases, and exports.

These water quality objectives and standards are designed to protect beneficial uses of Delta water categorized as municipal and industrial, agricultural, and fish and wildlife. The 1995 Bay-Delta Water Quality Control Plan contains an objective for dissolved oxygen levels (6.0 mg/L) on specified stretches of the San Joaquin River. D-1641 contains an estuarine habitat protection (X2) standard that is measured as EC (2.64 mS/cm) or Delta outflow criterion of 11,400 cfs or 29,200 cfs. Also included are narrative objectives for the protection of salmon and for the protection of brackish marshes of the Suisun Bay that implicitly list water quality measures.

During 2001, all agricultural EC standards were met at all Delta sites. All municipal and industrial chloride objectives were met with the exception of Contra Costa Canal when the 250 mg/L chloride standard was exceeded on October 14, 16, and 17 with measurements of 263 mg/L, 257 mg/L, and 257 mg/L, respectively. It was determined that the increase in chloride was due to local drainage as chloride measurements at nearby Delta locations were not in concurrence. All fish and wildlife EC objectives in the Delta and Suisun Marsh were met in 2001.

Monitoring of the DO concentrations in the Stockton Ship Channel was conducted from August 1 through December 5, 2001, covering 14 sites from Prisoner's Point to the Stockton Turning Basin. In the late summer and early fall, prior to the installation of the Head of Old River barrier, DO concentrations fell below 5.0 mg/L at sites from Rough and Ready Island downstream to Turner Cut. The fall installation of the

Old River at Head barrier is a commonly used remedy for low DO conditions in the lower San Joaquin River. DO conditions within the channel improved significantly by October 16 as DO concentrations rose to 6.0 mg/L or above throughout the channel. Increasingly cooler water temperatures coupled with reduction of reverse flows past Stockton played a part in the improvement. On November 14, 2001, continuing DO levels of 7.0 mg/L or above were confirmed throughout the channel. This sustained improvement negated the need for any further monitoring and the Old River barrier was removed on December 2.

The estuarine habitat protection standard (X2), in place from February through June, can be met with a specified number of days in which average daily EC is at or below 2.64 mS/cm at either Chipps Island or further upstream at Port Chicago. The X2 standard can also be met with flow criteria, measured as a 3-day running average of NDOI: 11,400 cfs for Chipps Island and 29,000 cfs for Port Chicago. During February through June 2001, the X2 standard was met at Chipps Island. During June, X2 was met at Collinsville, which is the default location used when PMI corresponds to 0 days at Chipps Island. X2 compliance at Collinsville was required and met for June.

Channel salinity in the Suisun Marsh is managed through the operation of the Suisun Marsh Salinity Control Gates from October 1 through May 31, as needed. The gates were operated from November 2000 to May 2001 in response to water quality concerns.

All Suisun Marsh salinity standards were met during 2001.

2. Introduction

Appendix E reports on the State Water Project's operation in the Sacramento-San Joaquin Delta as affected by Lake Oroville operations, water conditions, water demand, pumping operations, water quality standards, as well as environmental guidelines and initiatives. Additional reports, relating to SWP operations, documenting Delta fish and wildlife studies, water quality conditions, water supply operations, and monitoring research are available by consulting the Department's Publications and Paperwork Management Office's Web site at www.owe.water.ca.gov/information/pubs.cfm.

The State Water Project

The SWP is a system of reservoirs, power plants, pumping plants, and aqueducts that makes up one of the largest water and power systems in the world. The SWP begins in Plumas County where three small reservoirs make up the project's northernmost facilities—Antelope Lake, Frenchman Lake, and Lake Davis.

Downstream from these three reservoirs is Lake Oroville, the keystone of the SWP. Lake Oroville conserves water from the Feather River watershed. Contained by Oroville Dam, the tallest earth-fill dam in the Western Hemisphere, Lake Oroville is the project's largest storage facility, with a capacity of more than 3.5 maf. The map of the SWP (see Figure 2-1) identifies the major features of the SWP.

Water released from Lake Oroville flows through the Feather River and joins the Sacramento River, which drains the northern portion of California's great Central Valley and ultimately flows into the Sacramento-San Joaquin Delta. The SWP and CVP, as well as local agencies, all divert water from the Delta.

North Delta exports are diverted at Barker Slough Pumping Plant, providing water for Napa and Solano Counties via the North Bay Aqueduct. South Delta exports are diverted at Clifton Court Forebay where Banks Pumping Plant lifts water for delivery into Bethany Reservoir. The South Bay Pumping Plant, located at Bethany Reservoir, delivers water through the South Bay Aqueduct to Alameda and Santa Clara Counties, although most of the water from Bethany Reservoir eventually flows into the California Aqueduct for delivery to points south.

The 660-mile California Aqueduct winds along the west side of the San Joaquin Valley and transports water to O'Neill Forebay and San Luis Reservoir. The Department and the Bureau jointly own the 2 maf San Luis Reservoir, which stores both SWP and CVP water.

SWP and CVP water released from San Luis Reservoir flows south through the San Luis Canal, another SWP/CVP joint use facility. As the water continues to flow through the San Joaquin Valley, it has to be raised more than 1,000 feet by four pumping plants before reaching the foot of the Tehachapi Mountains.

In the San Joaquin Valley near Kettleman City, the Coastal Aqueduct serves agricultural areas west of the Aqueduct as well as municipal and industrial water users in San Luis Obispo and Santa Barbara Counties.

Figure 2-1. State Water Project

The remaining water conveyed by the Aqueduct is delivered to Southern California, but it must first cross the Tehachapi Mountains. The Edmonston Pumping Plant, located at the foot of these mountains, raises the water 1,926 feet — the highest single lift of any pumping plant in the world. The water then flows into Antelope Valley, where the Aqueduct divides into two branches — the East Branch and the West Branch.

The East Branch carries water through the Antelope Valley into Silverwood Lake, located in the San Bernardino Mountains. From Silverwood Lake, the water flows through the East Branch to Lake Perris, the southernmost SWP reservoir. The East Branch is currently being extended and will eventually carry water from the Devil Canyon Power Plant Afterbay to Cherry Valley, bringing water to Yucaipa, Calimesa, Beaumont, Banning, and other communities. Phase I will likely see completion in 2003, while Phase II is expected to be completed in 2015.

Water in the West Branch flows through the Warne Power Plant into Pyramid Lake in Los Angeles County; from there it flows through the Los Angeles Tunnel and Castaic Power Plant into Castaic Lake, the terminus of the West Branch.

Edmonston Pumping Plant, at the foot of the Tehachapi Mountains, is the highest single lift pumping plant in the world.

3. Water Supply and Deliveries

Water Supply

Precipitation and Runoff

Although water year 2001 (October 1, 2000, through September 30, 2001) started with an extremely wet month, precipitation waned and the year ended with a classification of *dry* under criteria set forth by SWRCB.

California depends on the northern Sierra Nevada as its major source of surface water where precipitation is indexed by averaging rain gauge totals at eight representative stations, creating what is known as the 8-Station Index. Water year 2001 provided 32.97 inches of precipitation at the eight stations of the northern Sierra, only 66 percent of historical average. By comparison, water year 2000 recorded 114 percent of average in the northern Sierra. Statewide rainfall amounted to 74 percent of average compared to 97 percent of average during water year 2000.

Sacramento Valley unimpaired runoff during water year 2001 was 9.8 maf, which represents 54 percent of average; the San Joaquin Valley unimpaired runoff was 65 percent of average (2.2 maf). Since State records began in 1906, unimpaired runoff in the Sacramento River Basin has ranged from a low of 5.1 maf in 1977 to as much as 37.7 maf in 1983.

October 2000 was quite wet throughout the State, providing false hope of another above-normal water year. Figure 3-1 illustrates the monthly precipitation totals in the northern Sierra, as well as the historical average. During October, the northern Sierra received 4.7 inches, (157 percent of average precipitation) while November and December recorded only 30 and 31 percent, respectively. Historically, January is the most productive month of the rainy season, but during January 2001 northern Sierra precipitation amounted to just over 5 inches (only 56 percent of average) .

February precipitation of 9.5 inches provided some welcome relief, far exceeding the historical average for the month. During each of the rest of the months through the water year's end, northern Sierra precipitation was below average. On September 30, 2001, the northern Sierra precipitation totaled almost 33 inches (about 66 percent of average), while statewide precipitation stood at 75 percent for the water year.

Snowpack

The April to July runoff from the snowpack of the western slope of the Sierra-Cascade Range provides approximately 40 percent of California's annual usable water supply. Snowpack water content is reported in monthly Department snow survey bulletins from February to May (cdec.water.ca.gov/snow/bulletin120). These measurements are used to predict the seasonal snowmelt runoff, known as the *April-July forecast.* The forecast for the Sacramento River Basin April-through-July runoff represents natural flow conditions (unaltered by upstream diversions) that would occur in the absence of constructed dams. The *Sacramento River Basin April-July forecast* for runoff was reported on May 1, 2001, as 56 percent (3.7 maf) of average and the observed April-July runoff totaled 52 percent (3.5 maf) of average. The *San Joaquin River Basin April-July forecast* on May 1 was

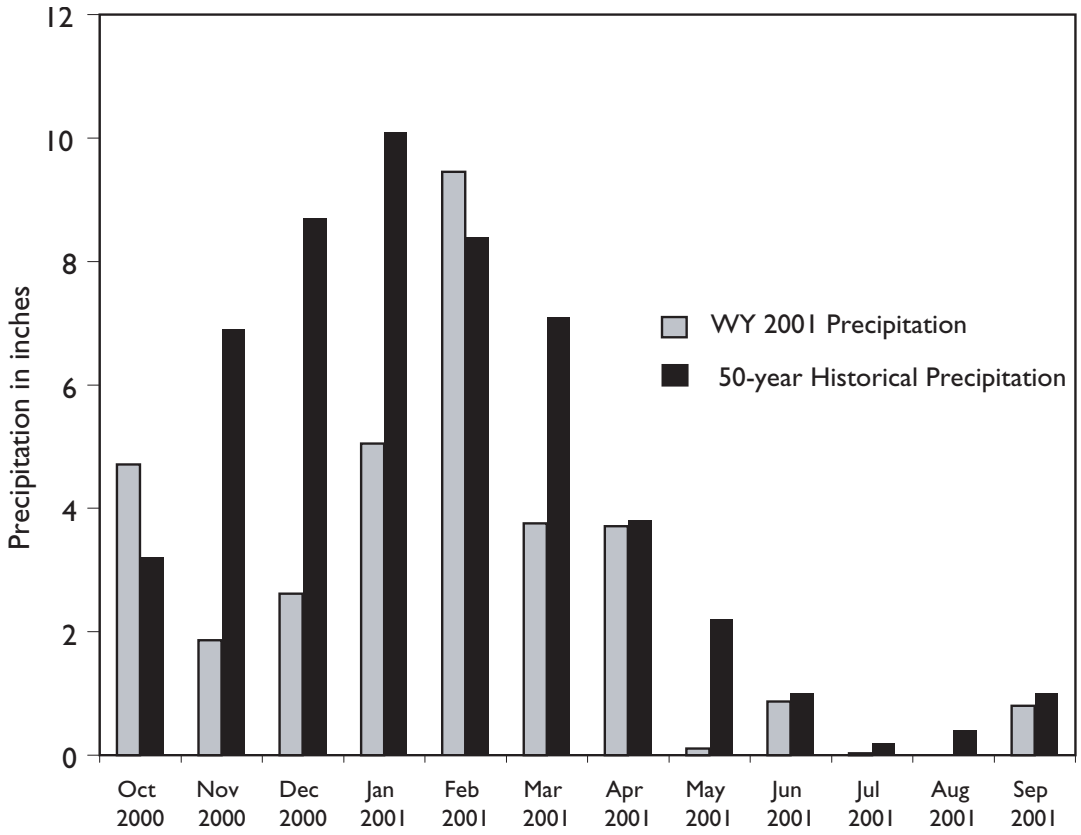


Figure 3-1. Precipitation average for water year 2001

70 percent (2.6 maf) of average, and the observed April-July runoff totaled 58 percent (about 2.2 maf) of average.

Historically, the April 1 snowpack water content measurement reveals the April-July snowpack at or near its peak; it is the most important factor in the prediction of seasonal snowmelt runoff. The snowpack peaked in mid-March during water year 2001 dropping to 60 percent of average on April 1. Although precipitation during April was slightly below average, a couple of stormy periods helped boost the snowpack to 65 percent of average on May 1. During May, the high Sierra snowpack melted at nearly twice the normal rate; record temperatures produced a 24 hour-per-day melt during the hottest portions of the month. By June 1, the only snow remaining was at the highest sheltered locations in the Sierra, providing scant runoff for June.

Reservoir Storage

Water year 2001 (October 1, 2000) began with carryover storage in the State's 156 major reservoirs at 24.2 maf (111 percent of average)—about 1.5 maf less than the previous water year's start. At the same time, the major reservoirs of the SWP (Oroville, San Luis, and the combined southern reservoirs) held 2.9 maf, about 0.7 maf less than at the start of water year 2000. Lake Oroville, the SWP's largest storage facility, held about 1.9 maf, which is about 0.5 maf less than last water year's start and about 84 percent of average.

On January 31, 2001, the State's 156 major reservoirs held 23.1 maf (97 percent of average) and SWP reservoirs remained constant at about 2.9 maf compared to 3.8 maf 1 year earlier. Lake Oroville storage fell to about 1.7 maf, in comparison to 2.35 maf on January 31, 2000. The State's share of San Luis Reservoir stood at 0.56 maf

compared to about 0.91 maf at the end of January 2000.

Abundant precipitation during February was followed by a drier than average March, April, and May. Consequently, on May 31, 2001, the State's 156 major reservoirs contained about 28.7 maf, 76 percent of capacity, and 97 percent of average. At the same time, the major SWP reservoirs held about 3.5 maf (80 percent of average) compared with about 4.5 maf on May 31 of last year. Storage at Lake Oroville on May 31, 2001, was about 2.1 maf compared to 3.1 maf at this time last year. Lake Oroville reached peak storage on May 6, 2001, at 2,203,836 af, or 62 percent of designed storage capacity. This storage peak represents the amount of water available for releases later in the year. On May 31, 2001, the State's share at San Luis Reservoir stood at 816 taf compared with 762 taf at the same time in the previous year.

A snow gauger prepares to plunge a snow tube through the snowpack. In California the snowpack is measured for both depth and water content.

At the end of the water year 2001 (September 30, 2001), the State's 156 major reservoirs held about 19.2 maf (87 percent of average) compared to 24.2 maf at the end of water year 2000. SWP major reservoirs contained about 2.57 maf in comparison to 2.87 maf at this time last year; Lake Oroville storage was about 42 percent of design capacity, holding approximately 1.49 maf (65 percent of average) compared to 1.92 at the end of water year 2000.

Nonproject Groundwater Turn-in Program

In April 2001, the Department restarted a water management program to accept nonproject groundwater turn-ins into the SWP. Turn-ins are authorized during periods of reduced SWP allocations. SWP contractors, or other participants of an approved program, convey groundwater into the Aqueduct. This water may be used for local redistribution, transfer to other contractors, or exchange with the Environmental Water Account.

Turn-ins have previously been utilized to boost available water supply during drought periods. In 2001, turn-ins not only added versatility to SWP water operations under dry year conditions, but also improved SWP water quality for some constituents south of Milepost 209. Turn-ins usually coincided with monthly decreases in total dissolved solids, conductivity, and organic carbon in the California Aqueduct, while slight increases in nitrate and sulfate also resulted. During 2001, SWP conveyed 154,972 af of water via the nonproject groundwater turn-ins.

Floodwater

During wet years, the Department occasionally accepts floodwater from the Kern River into the California Aqueduct through the Kern River-California Aqueduct Intertie under an Agreement among the State of California, Kern

County Water Agency, and the Kern River Interests for Diversions of Floodwaters through the Kern River-California Aqueduct Intertie, dated November 18, 1975. In 2001, the Department did not accept any floodwater into the California Aqueduct.

Water Supply Forecast Indices

Sacramento Valley

SWRCB 's D-1641 contains a water supply forecast tool called the *Sacramento Valley 40-30-30 Index,* which is used in the water budget operations studies as an indicator of available water supply. This index largely replaced its predecessor, the Sacramento River Index. SWRCB uses the Sacramento Valley 40-30-30 Index for classifying types of water years and establishing a corresponding level of protection for the Sacramento-San Joaquin Delta (Figure 3-2). The water year classification system also provides estimates of the potential water supply originating in a basin from rainfall, snowmelt runoff, groundwater accretion, and reservoir carryover storage.

The Sacramento Valley 40-30-30 Index incorporates seasonal differences in water contribution for the year and includes the prior year's conditions to establish a more reliable index of water available. The factors (40-30-30) represent the percentage weight given to:

(1) the forecasted or observed current year's April through July Sacramento Valley unimpaired runoff;
(2) the forecasted or observed current year's October through March Sacramento Valley unimpaired runoff; and
(3) the previous year's index with a cap of 10.

The Sacramento Valley unimpaired runoff sums the major flows into the Sacramento River Basin; it is also known as the Sacramento River Index. The Sacramento Valley unimpaired runoff for water year 2001 was 9.8 maf (51 percent of average).

The Department publishes forecasts on the Sacramento Valley 40-30-30 Index in monthly snow survey bulletins from February to May. The May 1 Sacramento Valley 40-30-30 Index forecast determines the water year type for water quality and flow requirements contained within D-1641. Most of these water quality and flow requirements are conditioned by water year type, generally becoming less stringent during drier years. On May 1, 2001, the Sacramento Valley 40-30-30 Index was forecast to be 5.9, resulting in the water year being classified as *dry* under D-1641 criteria. At the end of the water year, the actual Sacramento Valley 40-30-30 Water Year Classification Index was 5.8, also denoting a dry water year classification (Table 3-1).

San Joaquin Valley

D-1641 also calculates a *San Joaquin River Valley 60-20-20 Index*, which is calculated by methods similar to those used in the Sacramento Valley 40-30-30 Water Index (Figure 3-3). The San Joaquin Valley 60-20-20 Index at the 75 percent exceedence level determines the water year type for D-1641's Vernalis flow standards. The Sacramento Valley unimpaired runoff and corresponding San Joaquin Valley unimpaired runoff total are summed to produce the Eight River Index. This index is used to determine the duration of D-1641's habitat protection standard at Chipps Island and, under specific conditions, at Port Chicago from February through June. The San Joaquin River unimpaired runoff for water year 2001 (including the Stanislaus, Tuolumne, Merced, and upper San Joaquin Rivers) was 3.2 maf (54 percent of average). The May 1 forecast of the San Joaquin Valley 60-20-20 Index for water year 2001 was 2.4, resulting in the classification of *dry.*

Water Budget Process

The SWP satisfies percentages of long-term contractor's annual water requests within contractual agreements while assuring sufficient carryover storage is available to meet deliveries for Delta protection and emergencies in the

Year classification shall be determined by computation of the following equation:

INDEX = 0.4 * X + 0.3 * Y + 0.3 * Z

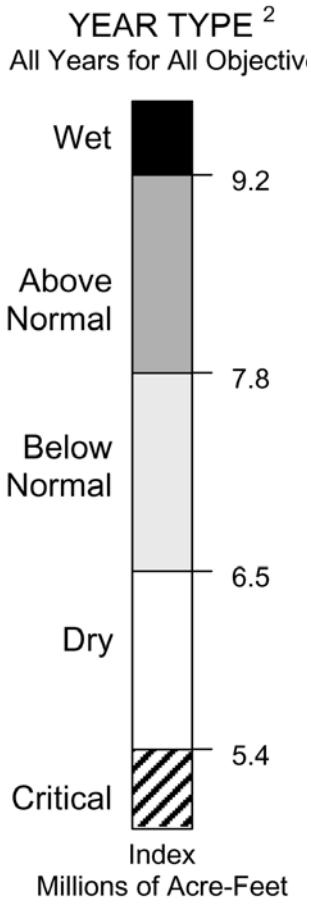
Where:
X = Current year's April – July Sacramento Valley unimpaired runoff

Y = Current October – March Sacramento Valley unimpaired runoff

Z = Previous year's index[1]

The Sacramento Valley unimpaired runoff for the current water year (October 1 of the preceding calendar year through September 30 of the current calendar year), as published in California Department of Water Resources Bulletin 120, is a forecast of the sum of the following locations: Sacramento River above Bend Bridge, near Red Bluff; Feather River, total inflow to Oroville Reservoir; Yuba River at Smartville; American River, total inflow to Folsom Reservoir. Preliminary determinations of year classification shall be made in February, March, and April with final determination in May. These preliminary determinations shall be based on hydrologic conditions to date plus forecasts of future runoff assuming normal precipitation for the remainder of the water year.

Classification	Index Millions of Acre-Feet (MAF)
Wet.....	Equal to or greater than 9.2
Above Normal.....	Greater than 7.8 and less than 9.2
Below Normal.....	Equal to or less than 7.8 and greater than 6.5
Dry.....	Equal to or less than 6.5 and greater than 5.4
Critical.....	Equal to or less than 5.4



1 A cap of 10.0 MAF is put on the previous year's index (Z) to account for required flood control reservoir releases during wet years.

2 The year type for the preceding water year will remain in effect until the initial forecast of unimpaired runoff for the current water year is available.

Figure 3-2. Sacramento Valley Water Year Hydrologic Conditions Index

Table 3-1. Sacramento Valley Water Year Hydrologic Conditions Index, Forecast and Actual Runoff, during Water Year 2001

Date of Forecast	Sacramento Valley 40-30-30 Index Probable Exceedence			Water Year Classification[a]	State Water Contractor Allocated Annual Table A Delivery (% of Request)[b]
	50%	*90%*	*99%*		
December 1, 2000	7.4	5.3		below normal	40
January 1, 2001	6.7		4.5	below normal	40
February 1	6.0		4.6	dry	20
March 1	6.3		5.1	dry	25
April 1	5.8		5.2	dry	30
May 1	5.9		5.5	dry	33
Sept 30	5.8			dry	39[c]
Actual water year unimpaired runoff		9.8 maf (54% of average)			
April-July forecast snowmelt runoff May 1 forecast		3.7 maf (56% of average)			
Actual unimpaired snowmelt runoff		3.5 maf (52% of average)			

[a]Probability exceedence at the median level (50%) is used to determine D-1641 water year class.

[b]Probability exceedence at the 90% level is used to forecast SWP water supply allocations in December and thereafter the 99% level is used.

[c]Annual Table A allocations were increased to 35% on May 17 and increased again to 39% on August 16, 2001.

following year. A balance between the State's water resources and contractor demand is met through the Water Budget Process.

The Water Budget Process makes annual forecasts based upon the following:

- reservoir capacity and storage at Lake Oroville, San Luis Reservoir, Lake Del Valle, and the four southern reservoirs;
- hydrology projections for the current year and future precipitation, runoff, and groundwater accretion (40-30-30 Index);
- operational constraints for environmental protection, recreation/fish and wildlife; and
- demands from contractors for agriculture, municipal, industrial uses, and other agencies, including the Bureau.

The Water Budget is an iterative water allocation process. Initial allocations for the coming year are made in December and are based on operations studies that assume 90 percent exceedence of historical water supply. Exceedence refers to the probability that unimpaired flow will exceed the historic water supply. Allocations are affected by water year forecasts updated at least monthly, using operations studies that begin in December.

SWP Water Deliveries

Monterey Agreement

The Monterey Agreement was executed by the Department and the SWP's long-term water contractors on December 1, 1994, establishing principles for amending the Department's SWP water contracts with the long-term contractors. The Agreement updated the management of the SWP by substantially revising SWP long-term contracts and their administration. The Monterey Agreement contains 14 principles that reflect the Agreement's goals to increase reliability of existing water supplies, provide stronger financial management of the SWP, and to increase water management flexibility by providing additional tools to local water agencies.

Year classification shall be determined by computation of the following equation:

INDEX = 0.6 * X + 0.2 * Y + 0.2 * Z

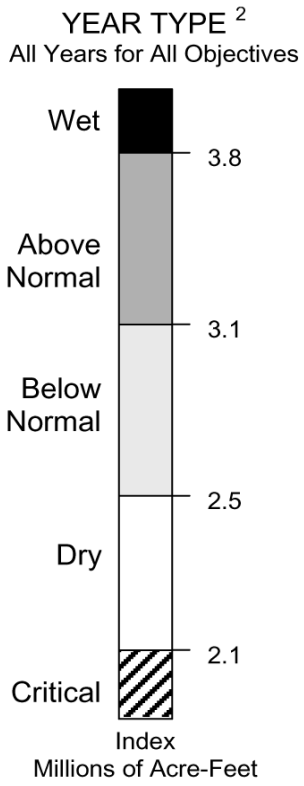
Where:
X = Current year's April – July San Joaquin Valley unimpaired runoff

Y = Current October – March San Joaquin Valley unimpaired runoff

Z = Previous year's index[1]

The San Joaquin Valley unimpaired runoff for the current water year (October 1 of the preceding calendar year through September 30 of the current calendar year), as published in California Department of Water Resources Bulletin 120, is a forecast of the sum of the following locations: Stanislaus River, total flow to New Melones Reservoir; Tuolumne River, total inflow to Don Pedro Reservoir; Merced River, total flow to Exchequer Reservoir; San Joaquin River, total inflow to Millerton Lake. Preliminary determinations of year classification shall be made in February, March, and April with final determination in May. These preliminary determinations shall be based on hydrologic conditions to date plus forecasts of future runoff assuming normal precipitation for the remainder of the water year.

Classification	Index Millions of Acre-Feet (MAF)
Wet……	Equal to or greater than 3.8
Above Normal…….	Greater than 3.1 and less than 3.8
Below Normal……..	Equal to or less than 3.1 and greater than 2.5
Dry……	Equal to or less than 2.5 and greater than 2.1
Critical……..	Equal to or less than 2.1



[1] A cap of 4.5 MAF is put on the previous year's index (Z) to account for required flood control reservoir releases during wet years.

[2] The year type for the preceding water year will remain in effect until the initial forecast of unimpaired runoff for the current water year is available.

Figure 3-3. San Joaquin Valley Water Year Hydrologic Conditions Index

Approved Table A Deliveries

SWP contractors' 2001 approved Table A amounts were initially scheduled at 1.65 maf, approximately 40 percent of their initial request. On January 31, 2001, unusually dry conditions caused the Department to reduce the scheduled approved Table A amounts to 20 percent. Abundant storms during February enabled the Department to increase that amount to 25 percent on March 6, 2001. Based on the amount of stored water and an updated snow survey, the Department increased approved Table A amounts to 30 percent on March 15, 33 percent on May 4, and 35 percent on May 17. On August 16, 2001, the SWP contractors approved Table A amount was increased once again to 39 percent, approximately 1.61 maf.

Actual Deliveries

In 2001, the SWP delivered 3,218,789 af to 27 of its 29 long-term contractors and to 17 other agencies. This is less than the water quantity delivered during 2000 by more than 1.7 maf. The following is a breakdown of the 2001 SWP deliveries:

- 1,615,934 af of approved Table A water;
- 43,182 af of Article 21 water and 253 af of unscheduled water;
- 74,992 af of Article 54 flexible storage withdrawal;
- 2,929 af of SWP water for recreation, fish and wildlife; and
- 1,556,491 af of water delivered to satisfy water rights settlement agreements and agreements with SWP contractors and other agencies, including the Bureau.

Water Deliveries to Non-SWP Agencies

In 2001, the Department used SWP facilities to convey non-SWP water for various agencies according to terms of water rights and water transfer and exchange agreements. The Department conveyed a total of 1,481,499 af of non-SWP water in 2001.

CVP Water

Included in the non-SWP water deliveries was 248,083 af that the Department conveyed for CVP through SWP facilities. CVP water was conveyed under SWRCB's D-1641 which allows the use of Banks Pumping Plant as a joint point of diversion for water supply to CVP. Conveyance was made in accordance with agreements negotiated with the Bureau and contractors receiving water from the Bureau through SWP as follows:

- Cross Valley Canal Contractors
- Kern National Wildlife Refuge
- Musco Olive Products, Incorporated
- The Bureau of Reclamation
- U.S. Department of Veteran Affairs

Water Rights Water

Water rights water is another category of non-SWP water transported through SWP facilities to long-term SWP contractors and other agencies according to terms of various local water rights agreements. In 2001, 1,101,481 af of water in this category was delivered to the Feather River, South Bay, and Southern California areas.

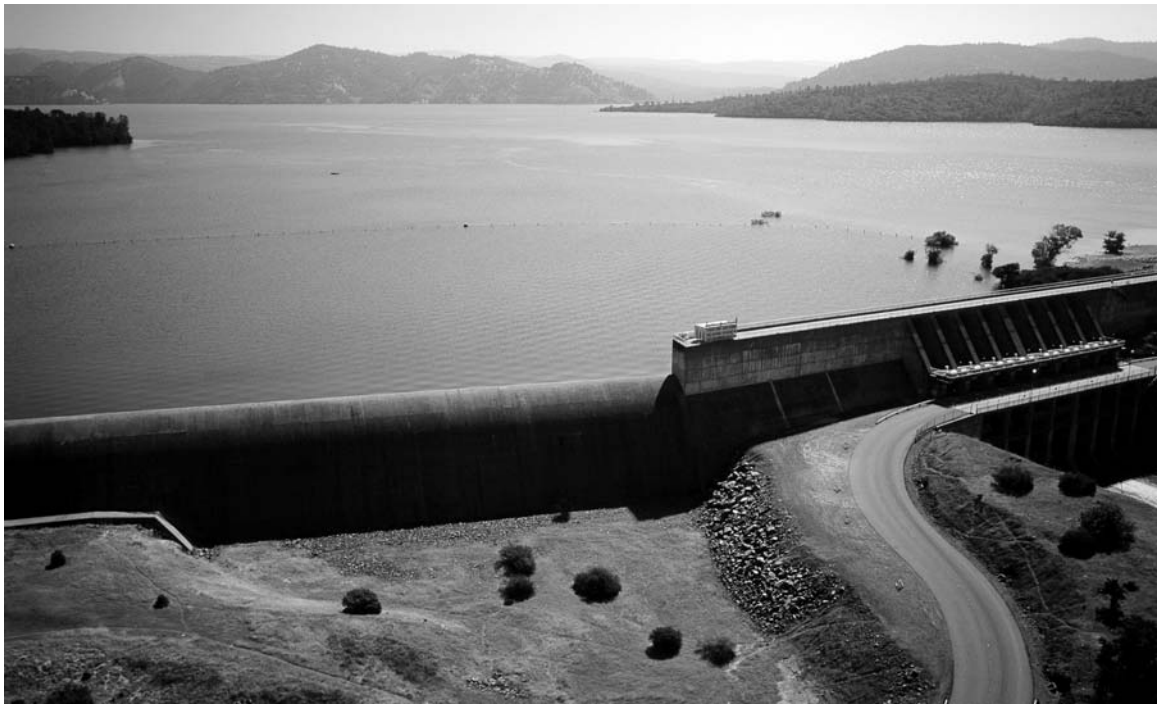
4. State Water Project Operations

The water operations data used in this report are preliminary and may not agree exactly with final figures; however, they are appropriate for use in this report. References to years are calendar years, except where noted.

Lake Oroville Operations

Lake Oroville operations alter seasonal flows in the Feather River and subsequently in the Sacramento River and the Sacramento-San Joaquin Delta by retaining a portion of the winter and spring runoff for release during the summer and fall. Flood control operations at Lake Oroville occur from October through June and help lessen extreme flood peaks thereby moderating flows entering the Delta (Table 4-1).

The Department and the Bureau proportionally meet Sacramento Basin and Delta water needs through SWP and CVP operations as specified in the 1986 Coordinated Operating Agreement. The application of COA operational measures is conditioned by flows into the Delta. Operations of both projects seek to balance exports with in-basin and fish and wildlife needs. Excess conditions allow greater flexibility in project operations; however, operations can be restricted during excess periods. A fish-related restriction applies when export pumping may impact



Lake Oroville, the second largest reservoir in California, is the keystone of the State Water Project.

Table 4-1. Monthly Summary of the Oroville-Thermalito Complex Operations during 2001 (cfs)

	Lake Oroville Inflow			Below Thermalito Outlet						Feather River Service Area	
				With SWP			Without SWP				
Month	*Average*	*Low Daily*	*High Daily*	*Average*	*Low Daily*	*High Daily*	*Average*	*Low Daily*	*High Daily*	*Mean Diversion*	*Mean Daily Return Flow*
Jan	2,593	1,443	3,744	2,138	1,750	2,720	2,109	549	3,084	629	145
Feb	3,293	1,457	8,956	1,750	1,750	1,750	3,293	1,457	8,956	0	0
Mar	4,874	2,686	9,066	1,750	1,750	1,750	4,874	2,686	9,066	0	0
April	3,971	1,901	5,875	1,390	1,050	1,804	3,523	1,728	5,469	591	143
May	3,599	884	8,857	2,588	1,835	3,415	1,714	252	6,578	2,839	793
June	1,551	593	2,854	2,668	2,213	3,948	267	104	499	2,699	463
July	1,570	702	3,145	2,247	2,216	2,731	201	-91	969	2,717	335
Aug	1,324	358	2,144	2,435	1,524	2,855	249	63	433	2,315	460
Sept	1,130	7	2,324	1,902	1,700	2,324	901	5	2,045	1,057	702
Oct	2,245	729	3,488	2,289	1,737	2,669	1,508	408	2,610	1,665	889
Nov	2,523	962	8,949	1,651	1,441	1,926	1,558	221	8,031	1,395	321
Dec	5,022	2,256	13,526	1,411	1,377	1,438	4,314	1,468	12,933	919	211

endangered or threatened Delta fisheries. Exports are also restricted during excess flows to balance the export/inflow ratios within set objectives. During late January 2001, operations were restricted as the result of a statewide electricity shortage. A fisheries restriction was in effect for about 46 percent of the 118 designated excess outflow days during 2001. In addition, an export restriction was in place for about 29 percent of the excess outflow days.

Delta conditions, as defined by the COA, fluctuated from balanced to excess conditions many times throughout 2001. The year began under excess conditions and ended under balanced conditons, accumulating 118 excess condition days by year's end.

Feather River Outflows

Water stored in Lake Oroville (Figure 4-1) is released through Hyatt Power Plant into the Thermalito Diversion Pool, and then travels through the Thermalito Diversion Dam into the Thermalito Power Canal, and then into the Thermalito Forebay. Water is released for electrical generation at the Thermalito Pumping-Generating Plant. Water then passes into the Thermalito Afterbay and is released to several local distribution systems for use in the Feather River Service Area or flows out to the Feather River via the Thermalito Afterbay river outlet. The Feather River low-flow channel is the pre-SWP river channel; it passes downstream of the hatchery and then merges with outflow from the Thermalito Afterbay river outlet, located 8.5 miles down river from the diversion dam. The 1983 Feather River Agreement with DFG sets minimum flow rates and specifies maximum temperatures on this low-flow channel.

Lake Oroville releases are routinely made for flood control, water supply, fish and wildlife protection, Delta water quality needs, and in response to unusual operational events. Flows are also released from the Thermalito Diversion Pool via the Thermalito Diversion Dam Power Plant to supply the low-flow channel of the Feather River and into a pipeline supplying the Feather River Fish Hatchery.

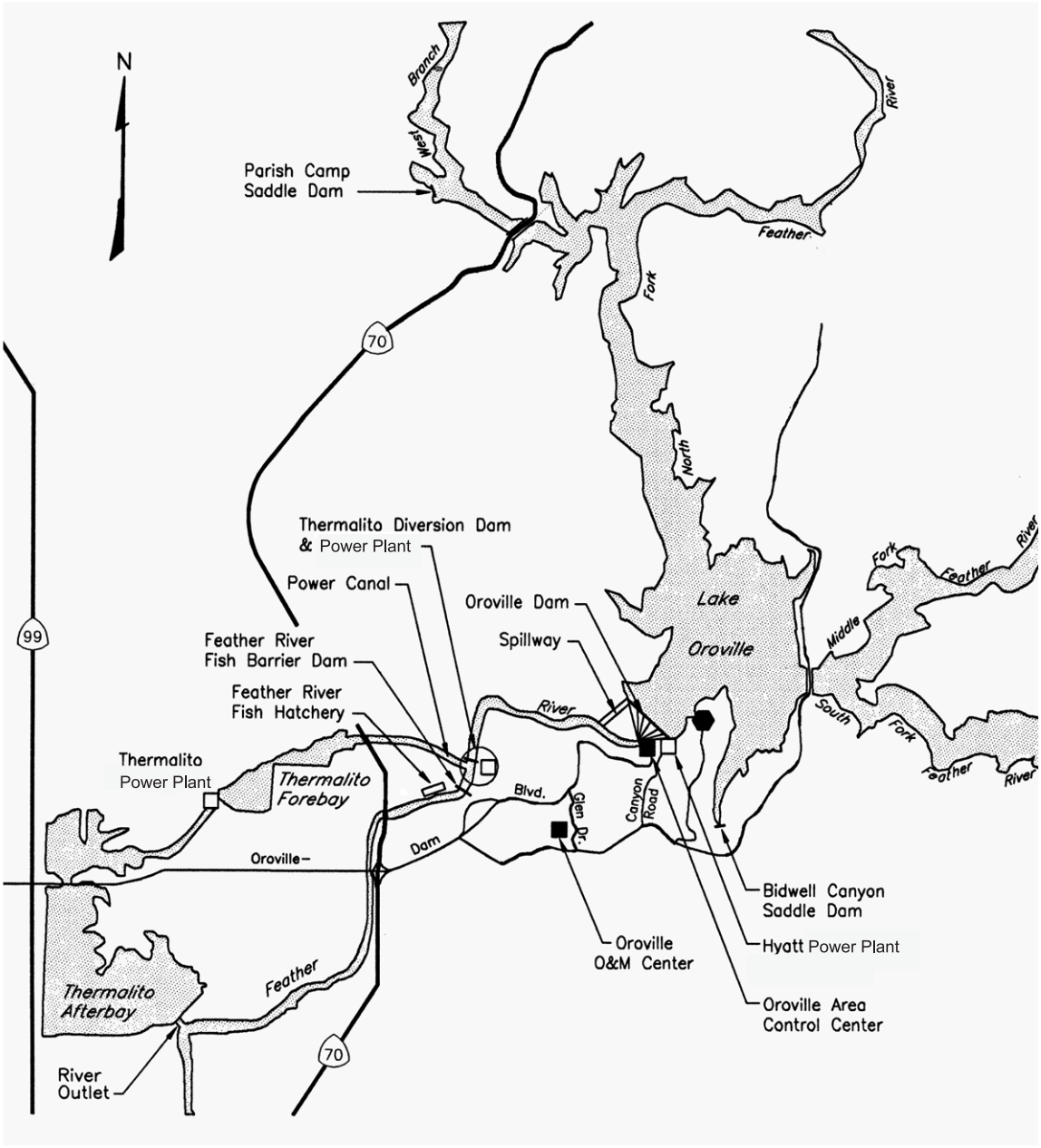


Figure 4-1. A map of the Oroville-Thermalito Complex

Lake Oroville Inflow, Releases, and Storage

Lake Oroville began water year 2001 with storage at 1.9 maf (54 percent capacity and 83 percent of average). This represents approximately 0.48 maf less than at the start of water year 2000. Lake Oroville inflow for water year 2001 was 1.89 maf (41 percent of average), significantly less than water year 2000's total of 3.99 maf.

Water year 2001 began on an optimistic note with October precipitation twice the average; however, November and December were very dry. Lake Oroville never received high winter inflows during water year 2001; in fact, inflows never exceeded 10,000 cfs. Inflows during January totaled only 159 taf, and increased to 183 taf and 300 taf during February and March, respectively. Inflows began to decline, with 236 taf in April and 221 taf in May. As in most years, June inflows showed a significant reduction, totaling 92 taf. September had the lowest monthly inflow, averaging only 4,437 cfs per day, and also the lowest daily inflow rate of 2001, averaging only 8 cfs on September 11. The highest mean daily inflow rate of 2001 occurred on December 31 at 13,551 cfs. For comparison, during 2000, the highest mean daily inflow rate of 56,044 cfs occurred on February 14.

Minimum storage at Lake Oroville occurred on September 29, 2001, at 1,483,999 af, about 42 percent of design capacity; peak storage occurred on May 6, 2001, at 62 percent of capacity (2,203,836 af); carryover storage at the end of water year 2001 was 1.49 maf, which is 42 percent of capacity (64 percent of average) (Table 4-2, Figure 4-2).

All Feather River flow and temperature criteria set in the 1983 DFG Feather River Agreement with the Department were met in 2001; however, on July 2, 2001, high temperatures caused the water in the Feather River low-flow channel to warm quickly, exceeding the 65.0 degree Fahrenheit objective set forth in the spring-run salmon and steelhead biological opinion. Additional water was released to the low-flow channel which resulted in the desired temperature reduction at the Robinson Riffle compliance point.

Feather River Service Area Diversions

Water deliveries are made to FRSA from the Oroville-Thermalito Complex for local water agencies and to satisfy water rights settlements that predate the construction of the SWP. The 2001 FRSA diversions totaled 1.08 maf and occurred during all months except February and March. FRSA returns water to the Feather River in the form of agricultural runoff and in 2001, the calculated return totaled 0.14 maf, or about 13 percent of the total diversion. The greatest amount of water was diverted during the months of May to October.

Table 4-2. Lake Oroville Storage during Water Year 2000-01

Date	maf	Percent of Capacity[a]	Percent of Historic Average
October 1, 2000	1.92	54	83
February 1, 2001	1.74	49	72
March 1, 2001	1.84	52	73
April 1, 2001	2.05	58	74
May 1, 2001	2.19	62	74
WY peak on May 6[b]	2.20	62	73
September 30, 2001	1.49	42	65

[a]Lake Oroville has a capacity of 3,537,580 af

[b]Peak daily storage during Water Year 2001 equaled 2,203,836 af

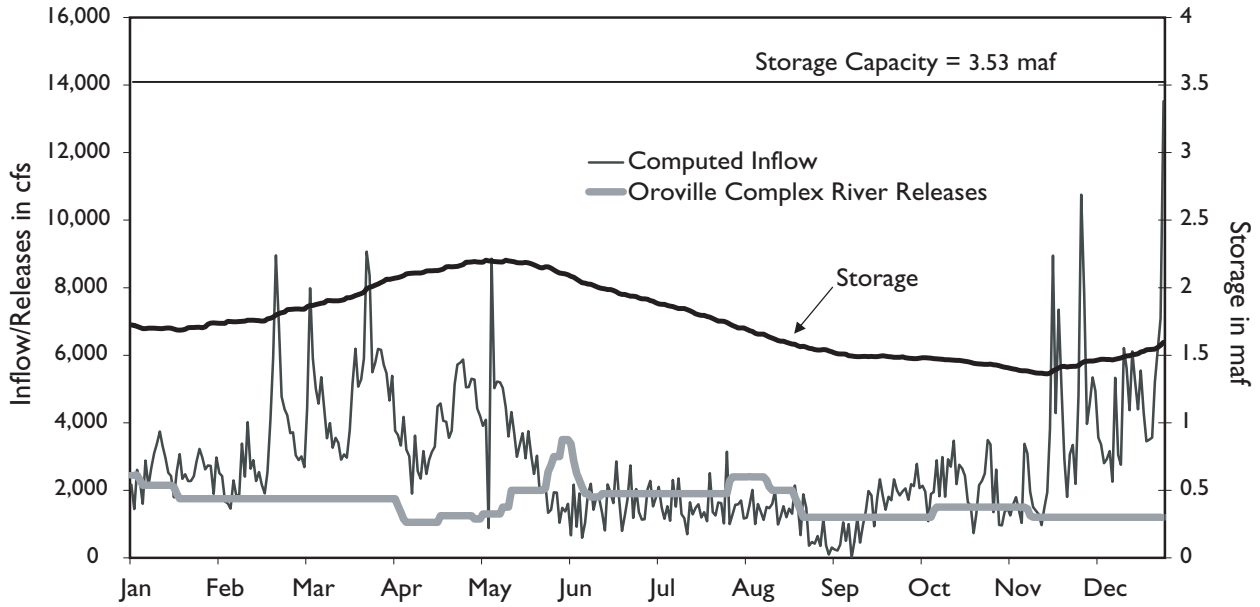


Figure 4-2. Lake Oroville inflow, releases, and storage during 2001

Effects of the Oroville-Thermalito Complex Water Operations on Feather and Sacramento River Flow

The operation of the Oroville-Thermalito Complex affects flows in the Feather and Sacramento Rivers. However, it takes approximately 2 days for the impact to be seen in the Sacramento River below Freeport.

The Department computes a *with SWP* (current project) and *without SWP* (pre-project) flow to describe the effects of Oroville-Thermalito Complex operation on both rivers, as defined below. Reservoir evaporative water losses are not included in these computations.

(1) The sum of Oroville-Thermalito Complex releases to the Feather River plus the estimated FRSA return flows defines the *with SWP* flow.

(2) The pre-project *without SWP* flow is calculated as Lake Oroville inflow minus deliveries to the FRSA (up to the limit of inflow), plus return flows from FRSA.

(3) The difference between the *with SWP* and *without SWP* flows is the approximated effect of SWP operations on Feather River flows.

Currently, most diversions to FRSA in the summer months exceed calculated pre-project Feather River flows. Under pre-project conditions (*without SWP)*, FRSA diversions from the Feather River could not have exceeded river flow. As a result, the *without SWP* average monthly flow cannot be computed directly from Table 4-1 summary data.

Augmentation

Sacramento and Feather River flows are considered to be augmented when the water released from the Oroville-Thermalito Complex exceeds the calculated pre-project flows. Feather River flow is often augmented as a result of Oroville-Thermalito releases executed for both evacuation of adequate flood control storage capacity in Lake Oroville and to meet conditions specified in the 1983 Feather River Agreement with DFG. Water from Lake Oroville is also released to meet Delta water quality and flow standards, ESA criteria, as well as SWP and non-SWP export needs at Banks Pumping Plant.

During 2001, the operations of the Oroville-Thermalito Complex augmented Sacramento and Feather River flows in January and from June through November; the highest flow augmentation occurred during June, July, and August.

Reduction

Feather and Sacramento River flows are considered reduced (designated by a negative value) when flow levels fall below pre-project conditions. In 2001, flows were reduced by project operations during high inflow periods occurring in December and from February through April. Monthly reductions were greatest during March (Tables 4-3 and 4-4, Figure 4-3).

Table 4-3. Effects of SWP Oroville Operations on Feather and Sacramento River Flow during 2001 (cfs)[a]

	Months with Mean Augmentation				Months with Mean Reduction		
	Mean (+)	*Minimum Augmentation*	*Maximum Augmentation*		*Mean (-)*	*Minimum Reduction*	*Maximum Reduction*
January	166	-1,292	2,168	December	-2,399	-8,597	56
May	551	-4,369	3,009	February	-1,475	-7,206	293
June	2,468	1,878	3,719	March	-2,959	-7,316	-936
July	2,047	1,393	2,822	April	-2,284	-4,411	-626
August	2,186	1,219	2,664				
September	1,122	-278	2,162				
October	788	-417	2,161				
November	133	-6,557	1,684				

[a]Comparison of present river flows that would have occurred without Oroville Dam.

Table 4-4. Monthly Summary of Sacramento River Flows during 2001 (cfs)

	At Freeport			At Rio Vista		
	Mean	*Low Daily*	*High Daily*	*Mean*	*Low Daily*	*High Daily*
Jan	17,254	11,752	28,992	10,871	6,635	24,720
Feb	20,967	12,286	36,808	17,159	10,162	31,397
Mar	24,744	14,311	46,216	21,393	12,137	39,504
Apr	12,317	9,599	14,188	9,677	7,471	11,513
May	9,157	7,150	12,149	6,413	4,759	8,909
Jun	12,302	11,409	15,166	8,372	5,780	9,345
Jul	14,773	13,735	15,698	6,990	6,339	7,746
Aug	12,981	11,728	14,576	5,903	5,070	7,058
Sep	12,364	11,594	13,323	5,795	5,344	6,421
Oct	8,337	7,181	11,100	3,349	2,519	5,429
Nov	12,483	8,720	22,204	6,357	3,833	13,472
Dec	27,449	17,813	36,204	22,097	9,266	30,753

Note: Flows between Freeport and Rio Vista may be diminished by diversions into the Delta Cross Channel or into Georgiana Slough.

SWP Delta Operations

Water levels and flow in the Sacramento-San Joaquin Delta are subject to sizable daily tidal fluctuations. Tidal changes in the Pacific Ocean cause flow reversal twice daily throughout much of the Delta. Flow in the Delta can also be affected by SWP and CVP pumping. SWP's Banks Pumping Plant begins the export of Delta water from Clifton Court Forebay into the California Aqueduct and nearby South Bay Aqueduct. Tracy Pumping Plant, located near Banks Pumping Plant, begins exports of CVP water into the Delta-Mendota Canal. The SWP also pumps water from the northern Delta at Barker Slough Pumping Plant into the North Bay Aqueduct.

State Water Project Operational Criteria

The Sacramento-San Joaquin Delta is an estuary and a navigable waterway subject to many State and federal laws that are designed to protect water quality, wetlands, anadromous and native fisheries, migratory birds, and threatened and endangered species. Table 4-5 lists the agreements, decisions, opinions, and rules that make up the institutional framework for SWP operations in the Sacramento-San Joaquin Delta. These operational criteria have a significant impact on water diversion from the Sacramento-San Joaquin Delta. With the exception of newly adopted criteria, the operational criteria will not be described further in this report. For additional information on these criteria, please refer to Bulletin 132-98 Appendix E.

During 2001, SWP operated under SWRCB's D-1641, which was adopted in December 1999. On March 15, 2000, SWRCB adopted Order WR 2000-02 amending D-1641 and denying petitions for reconsideration of the decision. D-1641 covers Phases 1-7 of the Bay-Delta Water Rights Hearings, leaving Phase 8, the allocation of responsibility for meeting the Delta outflow objectives, to be considered in early 2001. On April 26, 2001, SWRCB adopted WR 2001-5. This order stays the resumption of Phase 8 of the Bay-Delta Water Rights Hearing for 18 months. The order followed negotiations and formal agreement amongst the Sacramento River Basin water right holders. The order automatically dismisses Phase 8 at the end of the 18 months, unless SWRCB receives notice from the Department or the Bureau requesting resumption of Phase 8.

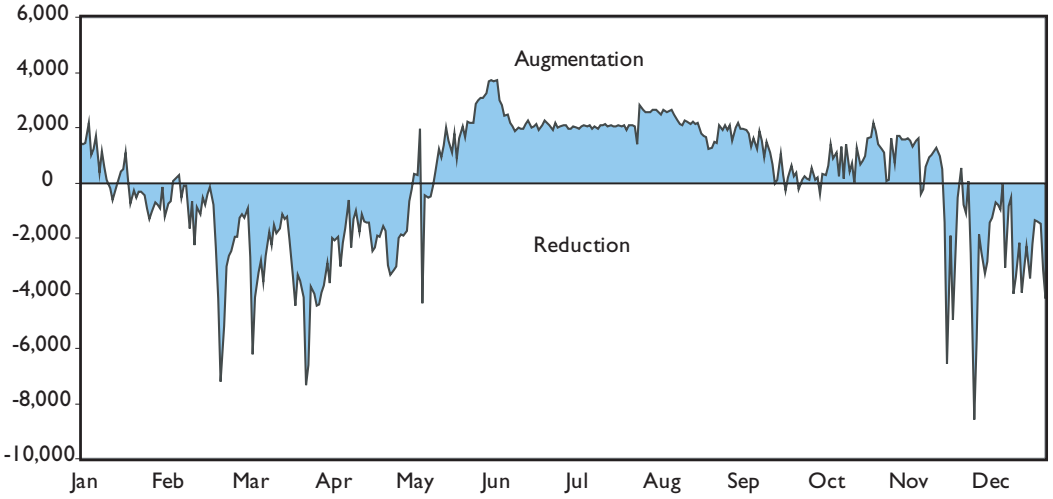


Figure 4-3. Effect of SWP operations on Feather River flow during 2001

Table 4-5. Institutional Framework for SWP Operations in the Sacramento-San Joaquin Delta during 2001

- Agreement between DWR and DFG concerning operations of the Oroville Division of the SWP for the management of fish and wildlife - 7/67 and 8/83
- U.S. Army Corps of Engineer's Section10 permit and Public Notice 5820-A 10/81. Permitted operations of Banks Pumping Plant.
- Agreement between the United States and State of California for Coordinated Operation of CVP and the SWP (COA) - 1986
- Agreement between DWR and DFG to offset direct fish losses in relation to the Banks Pumping Plant (Four Pumps Agreement) - 12/86
- Suisun Marsh Preservation Agreement signed by the Department, the Bureau, DFG, and SRCD - 3/87
- Central Valley Project Improvement Act (PL 102-575, Title 34) (CVPIA) - 9/92
- NOAA Fisheries Biological Opinion for Winter-run Salmon, long-term, 2/93. Amended 5/95 to conform to Bay/Delta Accord
- USFWS Formal Consultation on the 1994 Operation of the CVP and SWP: Effects on Delta Smelt (Long-term Biological Opinion) - 1/94, amended 3/95 to conform to the Bay/Delta Accord
- Framework Agreement between the Governor's Water Policy Council of the State of California and the Federal Ecosystem Directorate - 6/94
- Monterey Agreement - Statement of Principles by the State Water Contractors and the State of California Department of Water Resources for potential amendments to the State Water Supply contracts - 12/94
- Principles For Agreement On Bay-Delta Standards Between The State Of California and The Federal Government (Bay-Delta Accord) - 12/94
- Formal Consultation and Conference on Effects of Long-Term Operation of the Central Valley Project and State Water Project on the Threatened Delta Smelt, Delta Smelt Critical Habitat, and Proposed Threatened Sacramento Splittail, USFWS - 3/95
- Water Quality Control Plan for the San Francisco Bay /Sacramento-San Joaquin Estuary (1995 Bay-Delta Plan)
- SWRCB Water Right Decision 1641 - Conditions the water rights permits of the SWP and CVP to implement the water quality objectives of the 1995 Bay-Delta Water Quality Control Plan - 12/99
- Water Right Order 2000-02 - Order denying petitions for reconsideration and amending SWRCB Decision 1641 - 3/00
- Water Right Order 2001-05 - Order staying and dismissing Phase 8 of the Bay-Delta Water Right Hearing and amending revised Decision 1641 - 4/01

The CALFED Bay-Delta Program

The CALFED Bay-Delta Program began in 1995 to address environmental and water management problems associated with the Bay-Delta. It is a cooperative effort among State and federal agencies, urban and agricultural water users, fishing interests, environmental organizations, business interests and others, with a common goal of finding solutions to the problems facing the Bay-Delta. The Department has been an enthusiastic proponent of CALFED, recognizing it as a means of developing the State's water resources to the benefit of both the public and the environment, as well as fulfilling the water obligations of the SWP.

The Environmental Water Account was mandated by the CALFED Record of Decision signed on August 28, 2000. EWA is a cooperative water management program made up of five State and federal agencies. It was designed to help protect endangered and/or threatened fish species of the Bay-Delta estuary through environmentally beneficial changes in the operations of SWP and CVP, while ensuring the ability of the projects to continue to deliver water for agricultural and urban uses. EWA does not incur any uncompensated water cost to the projects' water users. Water year 2001, which began on October 1, 2000, was the first year of operation for EWA.

Delta Cross Channel Gate Operations

Sacramento River flow at Walnut Grove in the northern Delta (between Freeport and Rio Vista) can be diminished by water diversion into the Delta Cross Channel (gated diversion constructed and operated by the Bureau) or into Georgiana Slough, a natural channel just downstream of the Delta Cross Channel. DCC gates are operated in response to a variety of criteria relating to flow, water quality, and fisheries. D-1641 calls for closure of the DCC gates from February 1 until May 20; they may be closed for a total of 14 days, from May 21 through June 15. From November through January, the gates may also be closed for a total of 45 days for fisheries protection, as requested by USFWS, NOAA Fisheries, or DFG. During all these periods, the CALFED Operations Group determines timing and duration of gate closures.

The DCC gates were open for 192 days during 2001 (Figure 4-4). They were open during the

The Paintersville Bridge, near Courtland, was built in about 1929 to accomodate the steady shipment of fruits and vegetables from farms on both sides of the Sacramento River.

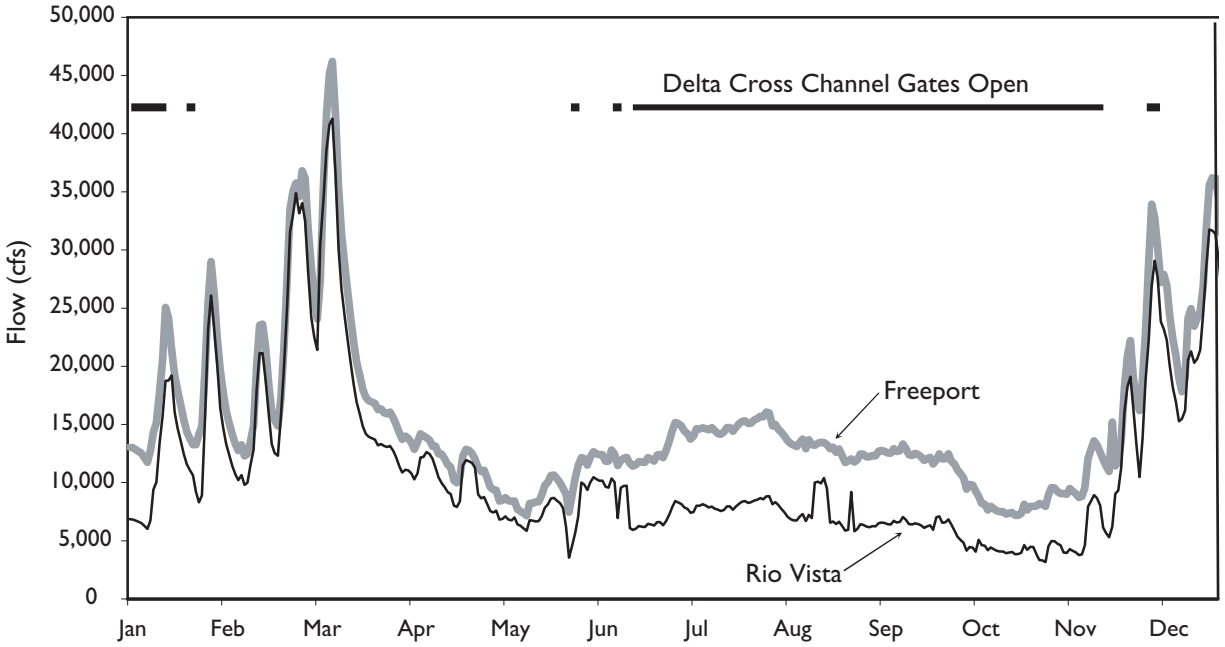


Figure 4-4. Sacramento River flows and Delta Cross Channel status during 2001

first half of January when Sacramento River flows remained below 25,000 cfs and closed on January 14 to protect juvenile winter-run salmon. On January 24, the gates were opened for 2 days but following that, the gates were closed until May 26. On the weekends of May 26-27 and June 9-10, the gates were opened to permit the passage of recreational boats through the Cross Channel. The gates were opened on June 15 and essentially remained open through November 21, with the exception of an experimental period during August, September, and October when they were operated tidally and at night during certain periods. On November 21, the gates were closed for the protection of out-migrating juvenile salmon and then subsequently reopened on November 29 due to serious water quality concerns in the Contra Costa Canal. The gates were closed again on December 4 (when precipitation brought Freeport flows up above 20,000 cfs) and remained closed through the end of the year.

Flow Standards

D-1641 sets flow rate standards for the San Joaquin River at Vernalis, the Sacramento River at Rio Vista, and the Delta using the Net Delta Outflow Index. Real-time fisheries monitoring is a tool used in determining the timing and duration of the San Joaquin River at Vernalis flow standard during April, May, and October. The 2001 Real-time Monitoring Program sampled fish at 59 Delta sites from March 18 through June 29. The RTM Data Summary Team provided a synopsis of the monitoring results, and recommendations to the CALFED Operations Group for making water project operational decisions. All flow objectives were met during 2001.

Vernalis Flow. Vernalis is located at the southernmost boundary of the Delta near the confluence of the Stanislaus and San Joaquin Rivers. The *Vernalis flow* represents the San Joaquin River's contribution to Delta inflow.

The Vernalis minimum monthly flow standard changes with water year type and is also dependant on whether the Habitat Protection Standard (X2) is met either west or east of Chipps Island. The San Joaquin Valley Index at the 75 percent exceedence level determines the

Vernalis water year type. During water year 2001, X2 compliance was attained at Chipps Island from February through May, requiring the higher base flow standard at Vernalis during those months. During June, X2 compliance was met at the default location, Collinsville, which triggers the lower base flow standard at Vernalis.

During dry years, the base flow minimum is set at 1,420 cfs (monthly or partial monthly average) for the San Joaquin River at Vernalis from February 1 through April 14 and May 16 through June 30 when X2 is met east of Chipps Island or Collinsville. An additional flow minimum of 1,000 cfs applies during October with the addition of 28,000 af pulse/attraction flow, to bring San Joaquin River flows up to 2,000 cfs. The CALFED Operations Group may also determine timing and duration of these flows based on real-time fisheries monitoring.

This Vernalis base flow objective helps to maintain a positive outflow through the central Delta while helping to minimize reverse flow conditions and fish entrainment at the export pumps. The 7-day average must not be less than 20 percent of period mean. The Vernalis monthly flow averaged 3,190 cfs, 3,562 cfs, and 2,280 cfs for February, March, and the first half of April 2001, respectively. Flows averaged 2,946 cfs during the latter half of May and were 1,624 cfs during June. October flows averaged 1,892 cfs while the pulse/attraction standard is 2,000 cfs for the month. In October 2001, the Bureau, DFG, and USFWS agreed upon a pulse flow operation that utilized New Melones Reservior and was designed to meet the October pulse/attraction flow standard. CALFED was also involved in the discussion of these flows. The base flow of the San Joaquin River during October fell short of the forecasted flow, resulting in the monthly flow average falling just short of the required 2,000 cfs. All Vernalis baseflow flow requirements were met during 2001 (Table 4-6, Figure 4-5).

D-1641 includes a spring pulse flow standard for the San Joaquin River at Vernalis, also conditioned by the San Joaquin Valley 60-20-20 Index

An aerial view of Little Mandeville Island looking south, with Old River in the foreground.

Table 4-6. San Joaquin River Flow Objectives Measured at Vernalis during 2001 (cfs)

Period	Objectives and Flows	
	Monthly or Period Mean[a]	*Actual Monthly or Period Mean*
Base Flow[b]		
Feb	1,420 or 2,280	3,190
Mar	1,420 or 2,280	3,562
Apr 1-14	1,420 or 2,280	2,280
May 16-31	1,420 or 2,280	2,946
Jun	1,420 or 2,280	1,624
Oct[c]	2,000	1,892
Pulse Flow[d]		
Apr 17 - May 17	4,450[e]	4,220
Combined exports limited by the Vernalis Adaptive Management Program[d] The Department is a participant in the San Joaquin River Agreement which facilitates VAMP.		
	Export Limit	*Combined Exports*
Apr 20 - May 20	1,500	1,420

Additional base flow criteria:

[a]Higher flow objective applied February through May as the 2 ppt isohaline (X2) objective was met at Chipps Island. During June, the lower flow objective applied as the X2 objective was met at Collinsville.

[b]7-day running average shall not be less than 20% below the flow rate objective.

[c]1,000 cfs plus an additional 28,000 af pulse/attraction flows to bring monthly average up to 2,000 cfs; timing is determined by CALFED Operations Group.

[d]SWRCB allows use of alternative San Joaquin flow and south Delta export targets contained within the Vernalis Adaptive Management Program.

[e]San Joaquin River pulse flow target was reduced to 3,200 cfs from March 23 through April 11 due to a differential in the forecasted and actual ungauged flow at Vernalis.

and the X2 compliance location. This spring pulse flow aids in transporting Delta smelt out of the southern and central Delta into Suisun Bay during their critical spawning period. The pulse flow's timing and duration is based on real-time fisheries monitoring to coincide with fish migration in the San Joaquin River and its tributaries.

The spring pulse flow period contained within D-1641 coincides with the Vernalis Adaptive Management Plan spring experimental period. VAMP export and flow criteria are recognized by SWRCB as a viable alternative to spring pulse flow criteria contained within D-1641. The Department and the Bureau are participants in the San Joaquin River Agreement, which facilitates VAMP. In spring 2001, the SWP and CVP used the spring pulse flow and export targets included in VAMP. This resulted in a flow target of 4,450 cfs, while actual flows averaged 4,220 cfs during the April 17 to May 17 pulse flow period.

Rio Vista Flow. Sacramento River flow at Rio Vista can be reduced by upstream diversions via the Delta Cross Channel, natural channels, and by Delta consumptive use, in addition to being opposed by tidal flow. D-1485 previously required year-round flow minimums at Rio Vista, but the 1999 adoption of D-1641 replaced D-1485, thus eliminating those minimums. D-1641 does set Rio Vista mean monthly flow minimums of 3,000 cfs, 4,000 cfs, and 4,500 cfs, for September, October, and November-December, respectively, for wet, above normal, below normal, and dry years. Flow minimums become less during critical years. During these

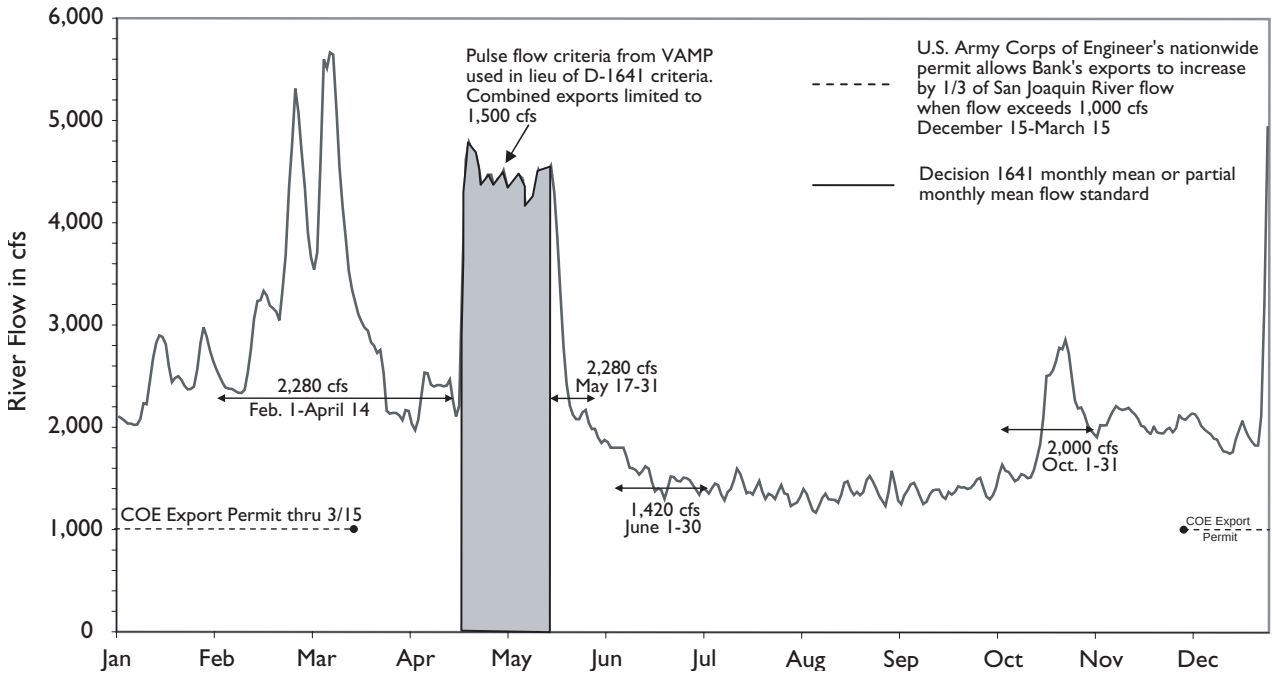


Figure 4-5. San Joaquin River flow standard and operational criteria at Vernalis during 2001

compliance periods, the 7-day running average daily mean cannot be more than 1,000 cfs below the required monthly average. During 2001, the Rio Vista mean monthly flow fell to its lowest level in October, averaging 4,242 cfs. All Rio Vista flow standards were met during 2001 (Table 4-7, Figure 4-6).

Net Delta Outflow Index. Actual measurements of net Delta outflow are impractical because of the effects of tide. However, since net outflow is one of the primary factors controlling Delta water quality, the Net Delta Outflow Index was developed as part of the Bay/Delta Accord. NDOI is derived using flows from the Sacramento River, the San Joaquin River at Vernalis, the Yolo Bypass, the Eastside stream system (the Mokelumne, Cosumnes, and Calaveras Rivers), some miscellaneous creeks, sloughs and canals, and discharges from the Sacramento Regional Wastewater Treatment Plant.

Major Delta exports and an estimated in-Delta water use factor is then deducted from the cumulative inflow total to produce the index.

D-1641 contains minimum monthly average NDOI standards for January and July-December. During January, the minimum monthly flow is set at 6,000 cfs when the previous month's Eight River Index (PMI) is greater than 800 taf; otherwise, it drops to 4,500 cfs. The dry-year minimum monthly NDOI objectives for July, August, September, and October are 4,000 cfs, 3,000 cfs, 3,000 cfs, and 3,000 cfs, respectively, and they rise to 3,500 cfs for November and December.

D-1641 also sets a habitat protection outflow from February through June, with a minimum daily NDOI of 7,100 cfs calculated as a 3-day running average. The objective may also be met by a daily average or 14-day running average EC of 2.64 mS/cm at Collinsville. Monthly NDOI habitat protection minimums for February through June are 7,100, 11,400, or 29,200 cfs depending upon whether X2 compliance is met at Collinsville, Chipps Island, or Port Chicago, respectively.

All NDOI standards were met during 2001 and the highest monthly average NDOI occurred in March with 23,152 cfs. The lowest monthly average occurred in August with 3,467 cfs (Figure 4-7, Table 4-8).

Table 4-7. Sacramento River Standards at Rio Vista for Dry Year 2001 (cfs)

	D-1641 Standards	Actual Flows	
Month	*Monthly average*	*Lowest 7-day average flow*[a]	*Monthly average flow*
Sep	3,000	6,180	6,472
Oct	4,000	3,839	4,242
Nov	4,500	3,956	8,006
Dec	4,500	15,302	23,847

[a]7-day running average shall not be less than 1,000 cfs below monthly standard.

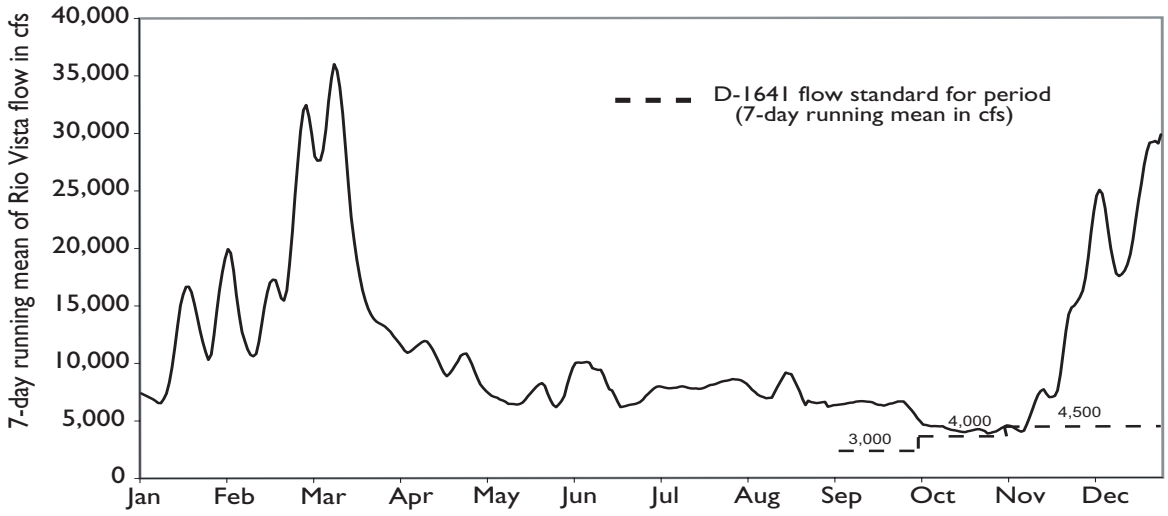


Figure 4-6. Sacramento River wet year flow minimums at Rio Vista during 2001

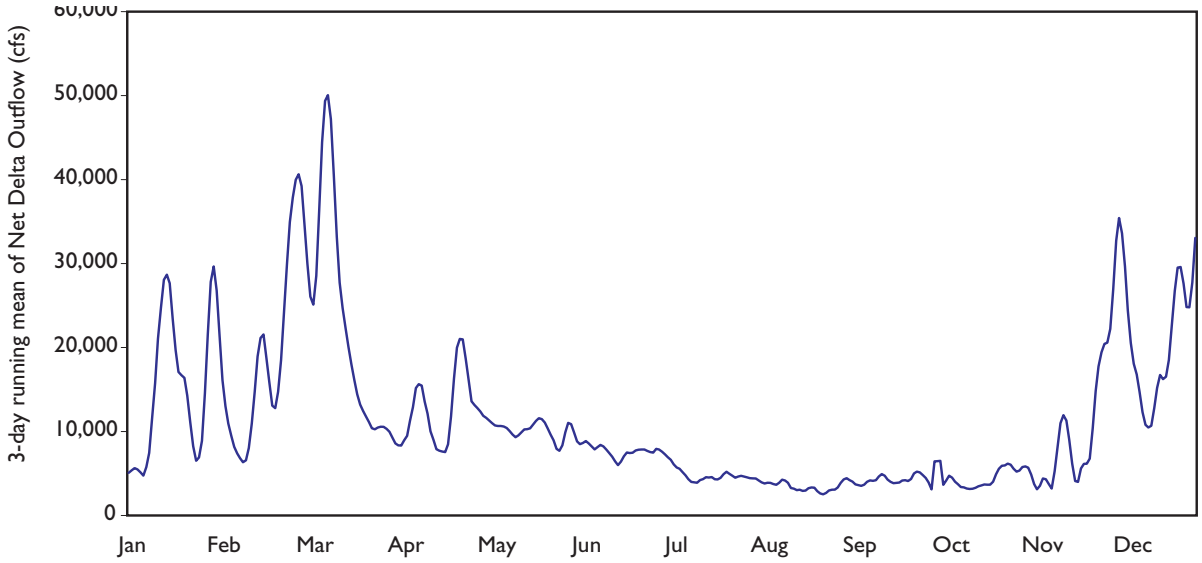


Figure 4-7. Net Delta Outflow Index during 2001

Table 4-8. D-1641 NDOI Flow Standards during 2001 (cfs)

Flow Standards	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
NDOI												
MM>	4,500[a]							5,000	3,500	3,000	4,000	4,500
Min. daily 3-dm		7,100[b]	7,100[c]	7,100	7,100[d]	7,100[d]						
Min. daily 14-dm												
Actual Flows												
MM	15,803	18,592	23,152	12,500	10,306	7,810	4,971	3,467	4,262	4,498	8,261	22,518
Min 3-dm flow		6,339	9,967	7,545	7,699	5,993						

Note: Shaded areas = standard; MM = mean monthly; 3-dm = 3-day mean; 14-dm =14-day mean

[a]If PMI >800 taf, January standard rises to 6,000 cfs.

[b]February 3-day mean flow standard was met with 14-day running average of EC <2.64 mS/cm.

[c]March standard may be relaxed if PMI is <500 taf.

[d]If May estimate of Sacramento River Index is <8.1 maf, May and June MM objective is set at 4,000 cfs.

Delta Exports

The Sacramento-San Joaquin Delta provides the major source of water for SWP deliveries south of the Delta. Inflow from the Kern River Intertie, groundwater turn-ins, and storm flows entering the California Aqueduct are also water sources for the SWP. Although there were no inflows from the Intertie or floodwater flows in 2001, water was received via nonproject groundwater turn-ins (see Chapter 3 for more information).

Banks Pumping Plant has the capacity to export water at a rate of 10,670 cfs, although the Aqueduct capacity below Banks Pumping Plant physically limits exports to 10,300 cfs. In addition, a Corps permit (Public Notice 5820A) limits the diversion rate at Clifton Court Forebay to 6,680 cfs, except from December 15 to March 15, when exports may increase by one-third of the San Joaquin River flow when its flow exceeds 1,000 cfs. San Joaquin River flow at Vernalis was in excess of 1,000 cfs throughout 2001, allowing corresponding increases in the export rate. Export pumping rates are increased on weekends to take advantage of less expensive off-peak electrical energy. This produces sharp peaks in the export rate at about 7-day intervals (Figure 4-8).

In 2001, the SWP diverted 2.31 maf at Banks Pumping Plant (about 62 percent of last year's exports of 3.74 maf) accounting for 72 percent of all SWP deliveries, both SWP contractual and noncontractual (3.21 maf). Under the 1986 COA, the SWP may export water for CVP later in the year to make up for exports not taken at its Tracy Pumping Plant under fisheries-related restrictions. D-1641 allows the SWP and CVP to use either project's pumping plants for exports to make up for export losses incurred for the protection of fisheries. These export exchanges may not jeopardize either project's deliveries and require permission from the CALFED Operations Group. During 2001 Banks Pumping Plant pumped 82,980 af of CVP and Cross Valley Canal water. (Table 4-9).

Winter-run Chinook Salmon Export Restrictions. The long-term Winter-run Chinook Salmon Biological Opinion, released in 1993 and amended in March 1995, can restrict Delta exports based on the combined loss of winter-run sized salmon smolt at the State and federal Delta export facilities, known as the *take level*. The Biological Opinion's incidental take statement invoked what is known as a *yellow light warning condition* when the combined loss (Banks and Tracy) reached 3,702 smolts, which is equivalent to 1 percent of the 2000 estimated

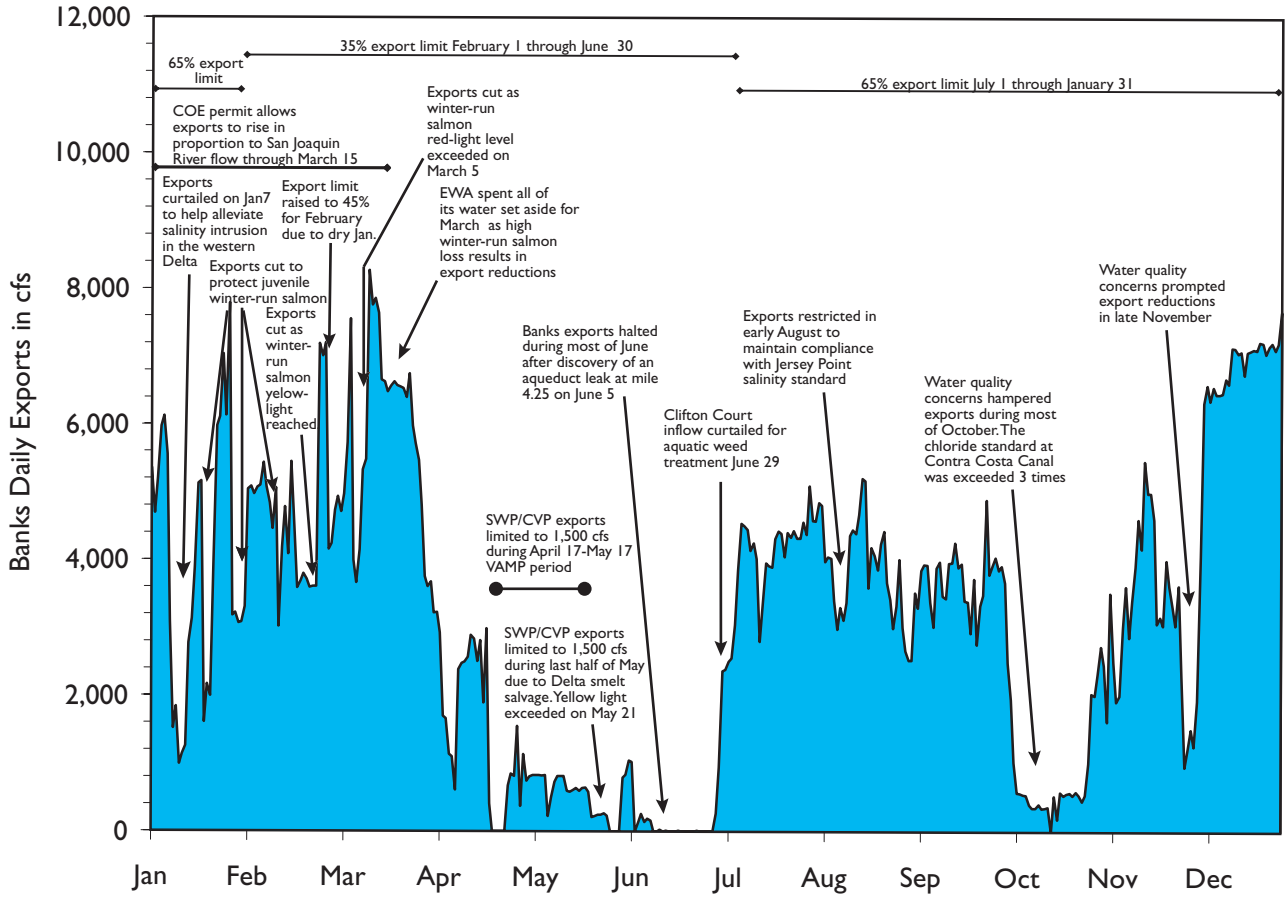


Figure 4-8. SWP Banks Pumping Plant exports during 2001, annotated with significant factors affecting export

Table 4-9. Delta Exports at Tracy and Banks Pumping Plants during 2001

Month	Export Rate SWP (cfs)	Banks Export For SWP (af)	Banks Export For CVP af)	Total Banks Exports (af)	Total Tracy Exports (af)	SWP/CVP Combined Exports (af)
Jan	121,639	240,845	0	240,845	168,299	409,144
Feb	131,744	260,853	0	260,853	195,466	456,319
Mar	182,197	360,751	0	360,751	115,793	476,544
Apr	49,762	98,528	0	98,528	129,557	228,085
May	17,082	33,823	0	33,823	52,673	86,496
Jun	4,663	9,233	0	9,233	178,317	187,550
Jul	109,932	177,288	40,377	217,665	254,284	471,949
Aug	125,525	186,518	62,021	248,539	253,969	502,508
Sep	107,423	172,339	40,359	212,698	242,817	455,515
Oct	30,458	60,306	0	60,306	222,497	282,803
Nov	97,059	192,176	0	192,176	223,095	415,271
Dec	190,178	376,553	0	376,553	225,704	602,257
Total	**—**	**2,169,213**	**142,757**	**2,311,970**	**2,262,471**	**4,574,441**

Fish salvage operations at the SWP Skinner Fish Facility

out-migrating juvenile winter-run salmon population. The Department and the Bureau voluntarily adjust pumping operations to reduce loss numbers when yellow light conditions are reached. Loss levels at 2 percent, or 7,404 smolts, trigger what is know as a *red light warning condition* and consultation with the Winter-run Chinook Salmon Monitoring Group is initiated. These yellow and red light export restrictions were in effect from October 2000 through May 2001, the predominant period of salmon migration.

The fish loss or estimated take is actually a calculated value derived from combined salvage numbers at SWP and CVP fish facilities, expanded by empirically determined factors including sampling duration, salvage efficiency, forebay predation, and losses due to handling and hauling.

As stated in Chapter 3, 2001 was the first year for operation of EWA. During January and February 2001, EWA salmon biologists concerned over the winter-run salmon loss to acre-foot pumped ratio, known as the *daily density of loss*, requested frequent SWP export curtailments (which were charged against EWA assets). On February 22, 2001, the winter-run salmon yellow light loss level of 3,702 smolts was exceeded and the Department initiated consultation with NOAA Fisheries and USFWS. Exports had already been cut from a combined 9,500 cfs to 7,000 cfs on February 16 for an 8-day period in reponse to increasing winter-run salmon loss and Delta smelt salvage. High winter-run salmon loss continued into March, exceeding the red light level (7,404 smolts) on March 5; the Bureau reinitiated consultation with NOAA Fisheries and USFWS on behalf of itself and the Department. Combined exports were further reduced on February 27 and the fisheries agencies extended the restriction to a combined 5,000 cfs through March 11, 2001. EWA assets for the protection of winter-run salmon were exhausted by March 11. The density of fish per acre-foot declined significantly after March 16, but the cumulative winter-run salmon loss continued to rise, reaching 19,848 by April 1. By May 31, the combined SWP/CVP seasonal winter run–salmon loss for 2001 totaled 20,008 smolts (Figure 4-9).

An important factor in the CVP/SWP consultations with NOAA Fisheries and USFWS was that 2001 was the first year that NOAA Fisheries considered using numbers derived from the adult salmon carcass survey rather than the traditional counts taken at the Red Bluff Diversion Dam to estimate the Juvenile Population Estimate. JPE is used to set the red light level. Had NOAA Fisheries used the carcass survey numbers to derive the JPE, the red light level for 2001 would have been about 53,000, well above the combined winter-run salmon loss (20,008). This large difference in JPE gave NOAA Fisheries confidence in deciding in winter-run salmon export curtailments after March 11. In 2002,

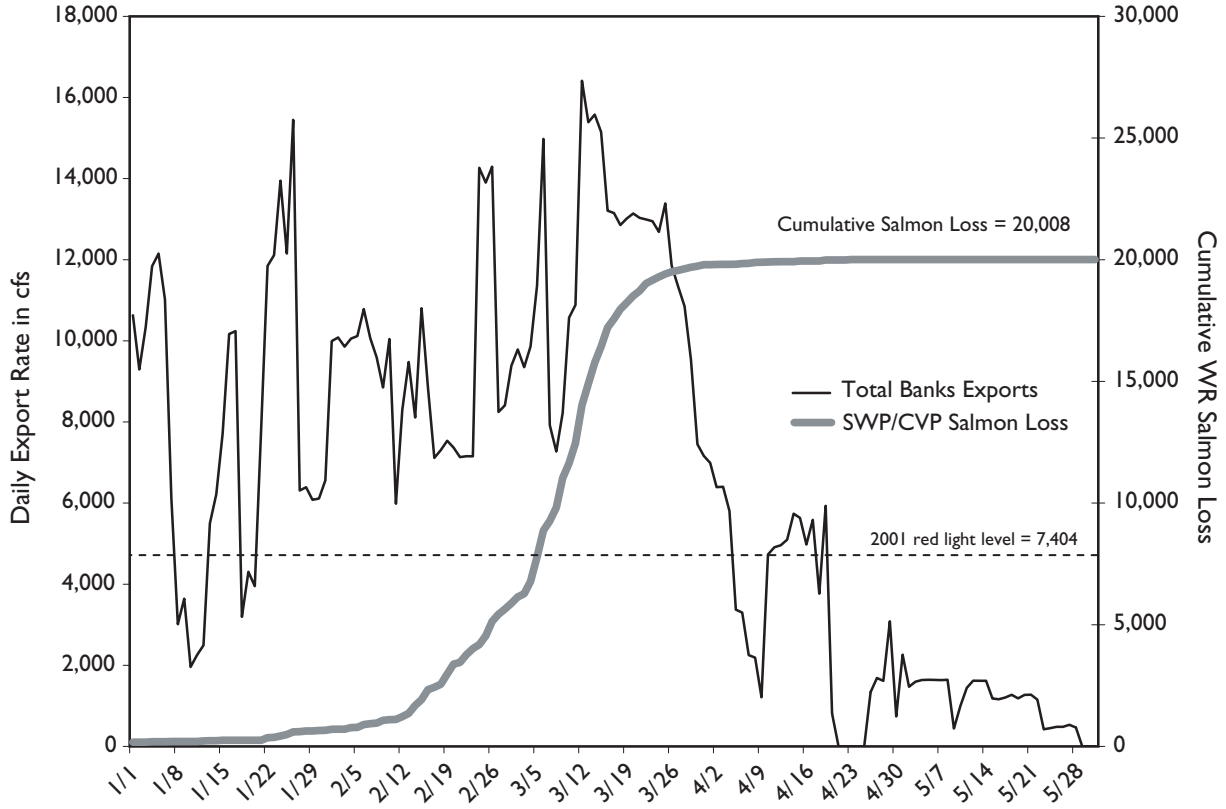


Figure 4-9. SWP/CVP cumulative winter-run salmon loss estimate and Banks total export, January 1, 2001, to May 31, 2001

NOAA Fisheries officially changed to using the carcass survey numbers to derive JPE.

Delta Smelt Export Restrictions. The amended Delta Smelt Biological Opinion established a year-round Delta smelt salvage action level of 400 fish (14-day running mean of daily salvage), known as the yellow light level that triggers informal consultation with USFWS, the Bureau, DFG, and the Department. The combined salvage is the sum of Delta smelt salvaged at Banks and Tracy Pumping Plants expanded by other factors similar to those used in the winter-run salmon calculation. The red light level is the cumulative total of the combined salvage for each month and varies by water year type, with below normal water years generally having a higher red light level than the level set for above normal water years. Red light levels for above normal water years are 2,378 for April and 9,769 for May, increasing to 1,245 for April and 55,277 for May during below normal water years. Reaching the red light level triggers formal consultation with the fisheries agencies to determine whether additional actions are necessary to avoid jeopardizing the species.

Delta smelt salvage spiked briefly in late February, but an export curtailment from a combined 9,500 cfs to 7,000 cfs helped the 14-day running average of salvage remain below the 400 fish yellow light level until late May.

During the VAMP period, which extended from April 17 to May 17, SWP exports remained relatively low at approximately 1,500 cfs. Exports at Banks Pumping Plant were scheduled to increase following the VAMP period. However, actual combined pumping during the last half of May was held to 1,500 cfs due to increasing salvage of Delta smelt. Despite export reductions, Delta smelt salvage rose steadily in late May. On May 21, the yellow light level of 400 Delta smelt was exceeded. Exports were allowed to increase

gradually to a combined maximum of 4,000 cfs from June 1-5. In 2001, export curtailments for the protection of Delta smelt were covered by asset expenditures from EWA. Unlike during several previous years, 2001 Delta smelt salvage never rose to the red light level (Figure 4-10).

Sacramento Splittail Salvage. USFWS listed the Sacramento splittail as threatened under FESA on February 8, 1999. The listing, which became effective on March 10, had been considered since 1994. During 2000, a Federal District Court judge found that the decision by USFWS to list the splittail as threatened under FESA was not reached in accordance with the law. The judge remanded the decision to USFWS for further analysis and review. In 2001, USFWS opened the ESA listing comment period on three separate occasions. A final rule is still pending. The Department and the Bureau have continued to meet with USFWS in an effort to establish an incidental take statement for operation of the SWP and CVP. Though no formal take limits for splittail were in place during 2001, the fish salvage facilities of the SWP and the CVP kept an accurate count of the combined splittail salvage. The combined salvage during 2001 is illustrated in Figure 4-11.

D-1641 Export Restrictions

D-1641 contains a year-round export standard, known as the *percent inflow diverted ratio* that restricts exports by limiting them in proportion to Delta inflow. The percent inflow diverted standard is the sum of SWP and CVP south Delta exports divided by Delta inflow. The percent inflow diverted standard is calculated using a 3-day running average of exports and a 14-day running average of Delta inflow. During periods when CVP or SWP exports are dependent upon storage withdrawals from upstream reservoirs, the percent inflow diverted ratio is computed using 3-day running averages of both export rate and Delta inflow.

This percent inflow diverted ratio standard varies by month and is conditioned by the previous month's Eight River Index. The combined CVP/SWP export standard is typically set at 35 percent of Delta inflow from February through June and 65 percent during January and the remainder of the year.

During January 2001, when the diversion of as much as 65 percent of Delta inflow is allowed for the month, the percent inflow diverted average was about 36 percent. Exports were severely curtailed in early January to help alleviate

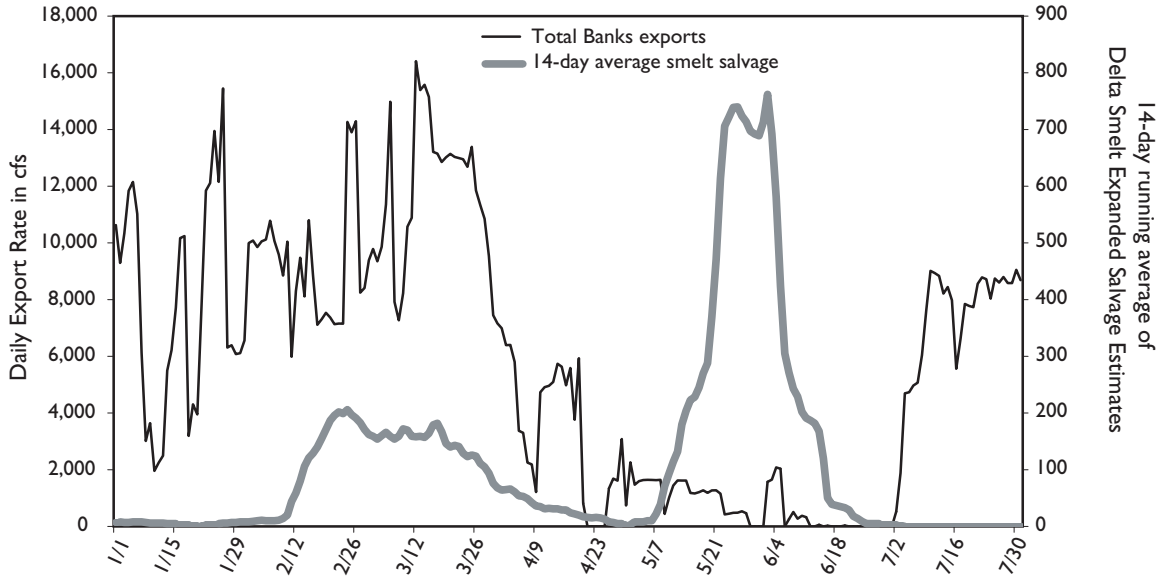


Figure 4-10. Expanded Delta smelt salvage estimates and Banks Pumping Plant exports during 2001

salinity intrusion and again during late January for the protection of juvenile winter-run salmon.

From February through June, the inflow diverted standard is 35 percent. During February 2001, the standard was raised to 45 percent because the January Eight River Index was less than 1.0 maf. February actually averaged 37 percent inflow diverted, in part due to concern over increasing salvage of Delta smelt and winter-run salmon which caused frequent export curtailments throughout the month.

The percent of diverted ratio averaged 20 percent from March through June, far less than the 35 percent standard. During the first half of March, exports were cut in response to high winter-run salmon loss. During April, SWP operations were complicated by a delay in the determination of X2 requirements caused by late March storms. Operations were also affected by low water levels in the south Delta. From April 20 to May 31 the combined SWP/CVP export rate was held at 1,500 cfs due to VAMP and Delta smelt concerns.

On June 5, 2001, a leak was discovered in the California Aqueduct at Milepost 4.25, in Alameda County, between Banks Pumping Plant and Bethany Reservoir. Around-the-clock work commenced to repair the 2 cfs leak that was located 29 feet under water. Dewatering of a 1,200-foot section of the Aqueduct was necessary to complete the repairs. Personnel from the Department's Environmental Services Division and the California Conservation Corps were called in to rescue fish trapped in the dewatered section of Aqueduct. During the repairs, some SWP contractor demands were met by releasing water from Lake Del Valle and via a temporary pumping plant that was installed in the CVP Delta-Mendota Canal, operated by the San Luis Delta-Mendota Water Authority, to meet additional demand. The Aqueduct was back in operation by July 6.

The Department filed for a temporary urgency permit to use Tracy Pumping Plant as a joint point of diversion for SWP exports. SWRCB

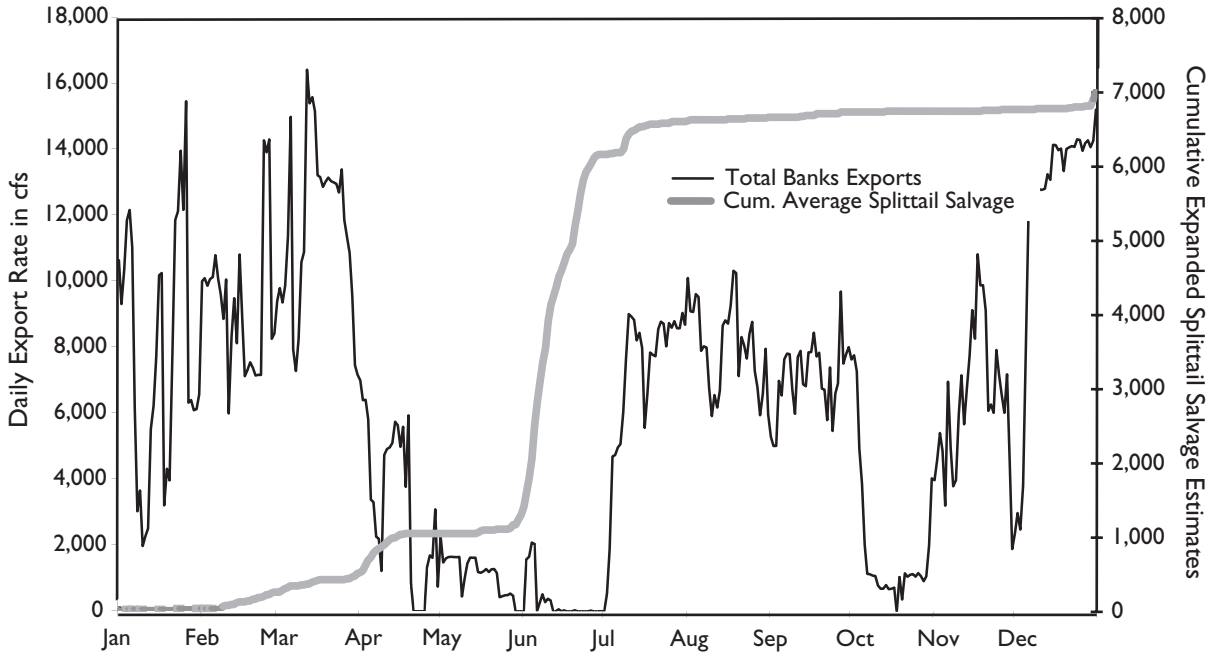


Figure 4-11. Expanded Sacramento splittail salvage estimates and Banks total exports during 2001

granted the petition and the CVP exported 11,000 af for the SWP from June 18-30, 2001.

From July through December, D-1641 allows combined exports to increase to 65 percent of Delta inflow — exports averaged 46 percent during this 6-month period. Exports were restricted in early August to maintain compliance with the 14-day average agricultural EC standard at Jersey Point. Compliance with the Contra Costa Canal 250 mg/L chloride standard was also a concern during August. During September, exports were reduced to help maintain sufficient Delta outflow to meet the NDOI standard for September of 3,000 cfs.

Delta outflow continued to be an important consideration for operations during October. In addition, water quality concerns hampered exports through much of October and November. The chloride standard at Contra Costa's Rock Slough Pumping Plant was a primary concern, as the standard was exceeded on October 14, 16, and 17. On November 21, the Delta Cross Channel gates were closed to protect juvenile salmon and by November 28, serious water quality concerns prompted a reopening of the DCC gates. Early December storms brought an end to the fall water quality problems.

Spring Export Restrictions. D-1641 also contains an export limitation applied during the spring pulse flow period on the San Joaquin River, limiting combined exports from April 15 through May 15 to 1,500 cfs, or 100 percent of the 3-day average of the San Joaquin River flow at Vernalis, whichever is greater. The San Joaquin River Agreement, completed in April 1998, includes VAMP, which contains SWRCB-approved alternate flow and export targets that may be used in lieu of the D-1641 criteria for the protection of San Joaquin River salmon. In 2001, the VAMP season extended from April 20 to May 20, during which SWP and CVP used 1,500 cfs as the combined export target. Actual exports averaged 1,420 cfs, which was about 9 percent of Delta inflow during this period.

All D-1641, ESA-related, and VAMP export criteria were met during 2001 (Figure 4-12, Table 4-10).

North Bay Aqueduct Operations

The North Bay Aqueduct system begins in the north Delta at the Barker Slough Facilities near Rio Vista. Sacramento River and local watershed water passes through Cache, Lindsey, and Barker sloughs to reach the Barker Slough Pumping Plant. From the Barker Slough Pumping Plant, water is conveyed by pipeline for 24 miles northwest to the Cordelia Pumping Plant. Deliveries are made to Solano County water users via turnouts along the pipeline and to Napa County users from the Cordelia Pumping Plant. NBA extends approximately 6 miles beyond the Cordelia Pumping Plant to the Napa Terminal Tank. This aqueduct will ultimately supply 25 taf annually to Napa County and 42 taf to Solano County. Deliveries to NBA totaled 43,931 af during 2001, about 1 percent of total SWP deliveries.

In 2001, NBA conveyed a total of 34,586 af for Solano County Water Agency—of which 17,756 af were approved Table A supply. Napa County received a total of 9,345 af—of which 4,293 af were approved Table A supply. Of the total 43,931 af delivered to both Napa and Solano, 3,300 af of water was delivered under Article 21 and 15,756 af was non-SWP water.

The Barker Slough Pumping Plant has a maximum pumping capacity of 160 cfs and is screened to exclude juvenile salmon from entrainment; however, the screens are not able to exclude the smaller Delta smelt. The amended Delta smelt opinion requires a reduction of diversions from Barker Slough to a 5-day running average of 65 cfs when Delta smelt under 20 millimeters are detected at three sites upstream of the plant. The running averages are calculated into a weighted average, with the weight of each station dependent upon the proximity to the Barker Slough pump intake. The opinion also set an estimated numerical loss

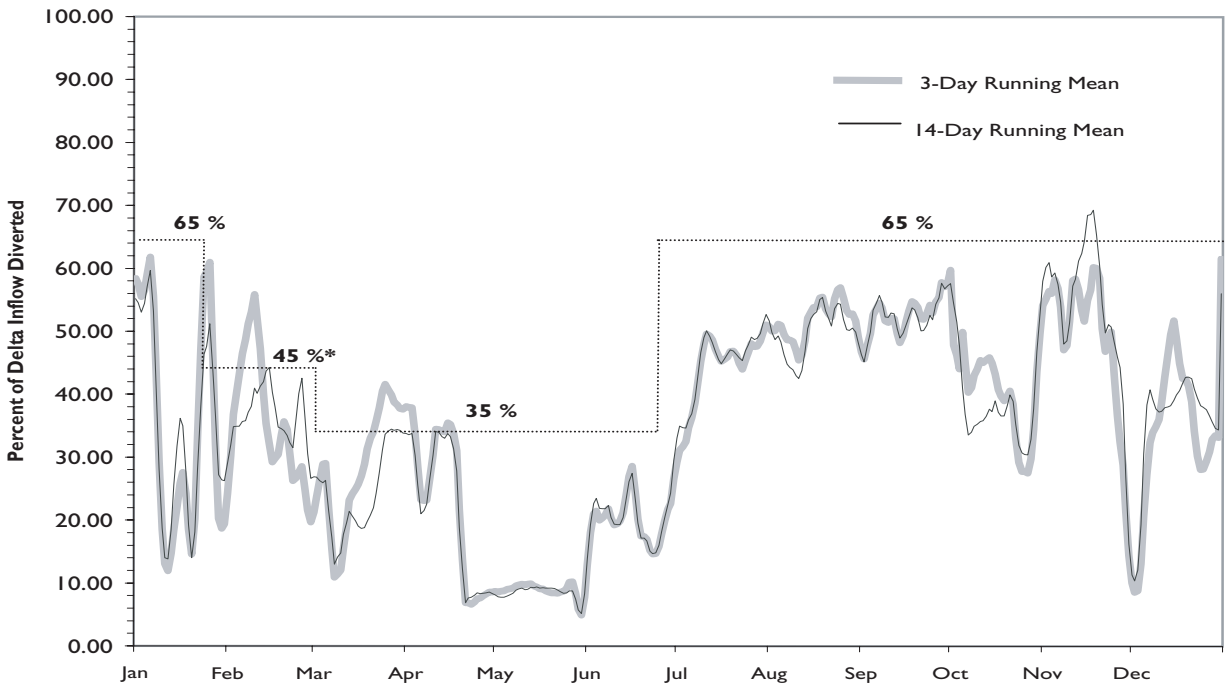


Figure 4-12. Combined Delta exports as percent of inflow diverted and D-1641 standards during 2001. Export limit was raised to 45% during February due to a dry January

Table 4-10. D-1641 Export Limits Based on Percentage of Delta Inflow Diverted during 2001

Month	Maximum % Inflow allowed as combined export (%)	Mean % inflow diverted	
		3-day running mean[a]	*14-day running mean*[a]
Jan	65	35.6	35.5
Feb	45	36.3	36.8
Mar		28.0	24.4
Apr[b]	35	23.9	22.6
May[b]		8.9	8.5
Jun[c]		19.5	19.7
Jul		43.1	44.1
Aug		51.8	49.9
Sep	65	52.2	52.0
Oct		41.3	39.1
Nov[d]		50.5	55.2
Dec		32.6	34.5

Note: Combined export is defined as Clifton Court Forebay inflow (minus BBID diversions from Clifton Court) plus Tracy Pumping Plant exports.

[a]Percent of Delta inflow diverted is calculated using the export rate as a 3-day running mean and the Delta inflow as a 14-day running mean, except when the SWP or CVP are making storage withdrawals for export. In this case, both the export rate and Delta inflow are 3-day running means.

[b]VAMP provides alternative spring pulse flow and export criteria that is recognized by SWRCB and is used in lieu of D-1641 criteria.

limit at the pumping plant during Delta smelt spawning season.

During the Delta smelt monitoring season, February 15 to July 14, 2001, NBA did experience export reductions in late May and early June due to the presence of Delta smelt. During the balance of the 5-month period, the Department did not receive timely data reporting that the Delta smelt catch at the three Barker Slough stations had risen to the level described in the amended Delta Smelt Biological Opinion to establish Delta smelt presence or, when timely data indicating the presence of Delta smelt was received, exports were already below the 5-day running average of 65 cfs.

Delta Water Management

South Delta Improvements Program

During the latter half of the 1990s, the Department sought to accelerate the construction of south Delta facilities to improve Delta water conditions. This was accomplished through the Interim South Delta Program. In 1999, the CALFED Bay-Delta Program decided to include south Delta facilities as a key component of the CALFED decision-making process. ISDP was subsequently renamed the *South Delta Improvements Program* and its purpose was revised to focus on the following issues:

(1) improve the reliability of existing SWP facilities;
(2) ensure that water of adequate quantity and quality is available for diversion to the South Delta Water Agency service area for beneficial use; and
(3) reduce the effects of SWP exports on both aquatic resources and direct losses of fish in the south Delta.

A preferred plan is being developed for SDIP as part of the ongoing process of preparing project-specific environmental documentation. Planning activities for increasing Banks Pumping Plant to the 10,300 cfs export maximum continued during 2001. The proposed project includes the construction of a new screened intake to Clifton Court Forebay and four permanent, operable flow control facilities in south Delta channels that would replace the temporary rock barriers that are currently in use. These improvements are key components of the CALFED Conveyance Program and they would improve SWP water supply reliability and

The Clifton Court Forebay is a water-regulating reservoir for the operation of Banks Pumping Plant and allows diversions from the Delta to coincide with favorable tide conditions.

increase operational flexibility. In addition, the construction of flow control structures in south Delta channels would allow the Department and the Bureau to improve conditions for local agricultural diverters in the vicinity of SWP and CVP south Delta export facilities.

South Delta Temporary Barriers Project

The Department has constructed seasonal barriers under the program's South Delta Temporary Barriers Project since 1990 to improve south Delta water conditions and collect data for the design and operation of proposed permanent barriers. The temporary barriers have been placed across Middle River, Old River at Tracy, Grant Line Canal, and at Old River at Head (Figure 4-13).

The barrier at Old River at Head prevents San Joaquin River flow from entering Old River and flowing toward SWP and CVP export facilities. The additional flow in the San Joaquin River is intended to guide juvenile salmon to the ocean in the spring and improves San Joaquin River dissolved oxygen levels for salmon migrating upstream in the fall to spawn.

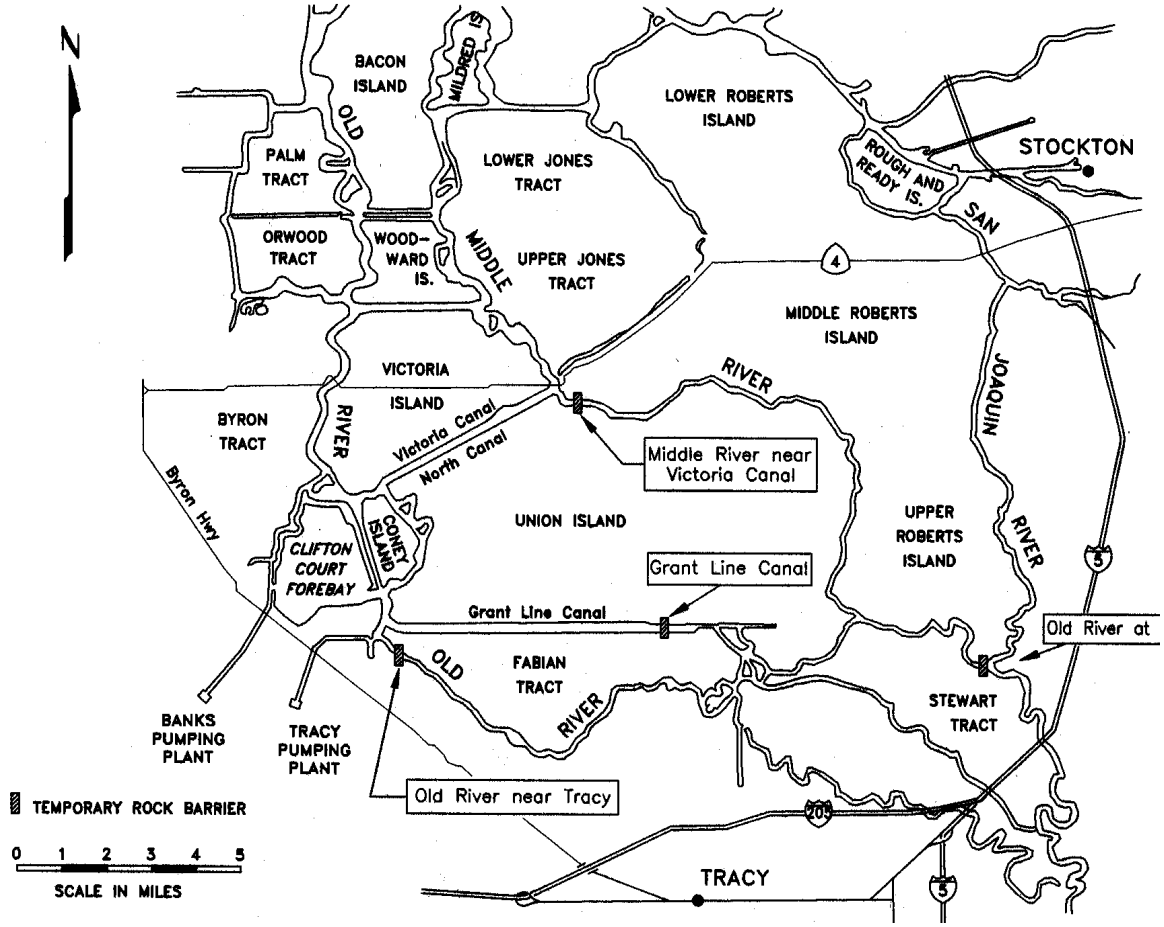


Figure 4-13. South Delta temporary barrier locations are shown.

The Department is obligated under the San Joaquin River Agreement, which facilitates the implementation of VAMP, to install and operate the Old River at Head barrier in a manner that will protect San Joaquin River Chinook salmon smolts in conjunction with the flows provided during the pulse flow period. During spring 2001, the Old River at Head barrier was installed by April 26 and was removed by May 30. In the fall, the Old River at Head barrier was installed on October 6 and its removal was completed on December 2, 2001.

The Middle River barrier is a temporary rock barrier installed near Victoria Canal, located about one-half mile south of the confluence of Middle River and Trapper Slough. This tidally controlled barrier improves water circulation and water levels during the agricultural irrigation season. The Middle River barrier was installed on April 23 and removal was completed on November 17, 2001.

The Old River barrier near Tracy has been installed annually in spring since 1991. The barrier is installed on Old River, one-half mile east of Tracy Pumping Plant. The Old River barrier near Tracy provides similar benefits to those of the Middle River barrier. It was installed on April 26 and removed by November 26, 2001.

The Department began the annual installation of the Grant Line Canal barrier east of Tracy Boulevard Bridge in 1996. This barrier provides benefits similar to those of the Middle River barrier. The Grant Line Canal barrier was installed on June 1 and removal of the barrier was completed November 18, 2001 (Table 4-11).

Table 4-11. Dates of Installation and Removal of Temporary South Delta Barriers during 2001[a]

Barriers	Installation Dates Completed	Removal Dates Completed
Middle River	April 23, 2001	November 17, 2001
Old River near Tracy	April 26, 2001	November 26, 2001
Old River at Head		
Spring barrier	April 26, 2001	May 30, 2001
Fall barrier	October 6, 2001	December 2, 2001
Grant Line Canal barrier	May 6, 2001	November 18, 2001

[a]South Delta Improvements Program - South Delta Temporary Barriers Project

5. Delta Water Quality Standards

Water quality in the Sacramento-San Joaquin Delta is influenced by the quality and quantity of tributary inflows, regulated discharges, and agricultural drainage, including drainage from Delta islands, seawater intrusion into the Delta's western channels, water diversions, and by operations of the SWP and CVP. The SWP and CVP are required, under their SWRCB water right permits, to meet the water quality objectives in SWRCB's D-1641, which was designed to protect the beneficial uses of Delta water. The Bay-Delta Accord, also referred to as the Principles of Agreement, was designed to balance proposed SWRCB's water quality standards and ESA operational criteria, with the need to provide water supply reliability.

Water quality standards and objectives are categorized by the beneficial uses they are intended to protect under broad categories that include municipal and industrial, agricultural, and fish and wildlife. The water quality compliance stations, including Suisun Marsh sites, are shown in Figure 5-1. The Department utilizes the following measures to meet D-1641 water quality and flow standards: (1) releases from upstream reservoirs; (2) operation of the Delta Cross Channel Gates; (3) modification of Delta pumping operations; (4) the construction of temporary rock barriers (see Chapter 4); and the operation of the Suisun Marsh Salinity Control Gates.

D-1641 incorporates the D-1422 San Joaquin River salinity standard at Vernalis. A multi-location San Joaquin River dissolved oxygen objective is contained within the 1995 Bay-Delta Water Quality Control Plan. The Bay-Delta Plan also introduced a narrative objective for salmon protection and for the protection of brackish tidal marshes of Suisun Bay. Operational standards are summarized in Table 5-1.

A sound, well-maintained levee system is vital to protecting Delta water quality.

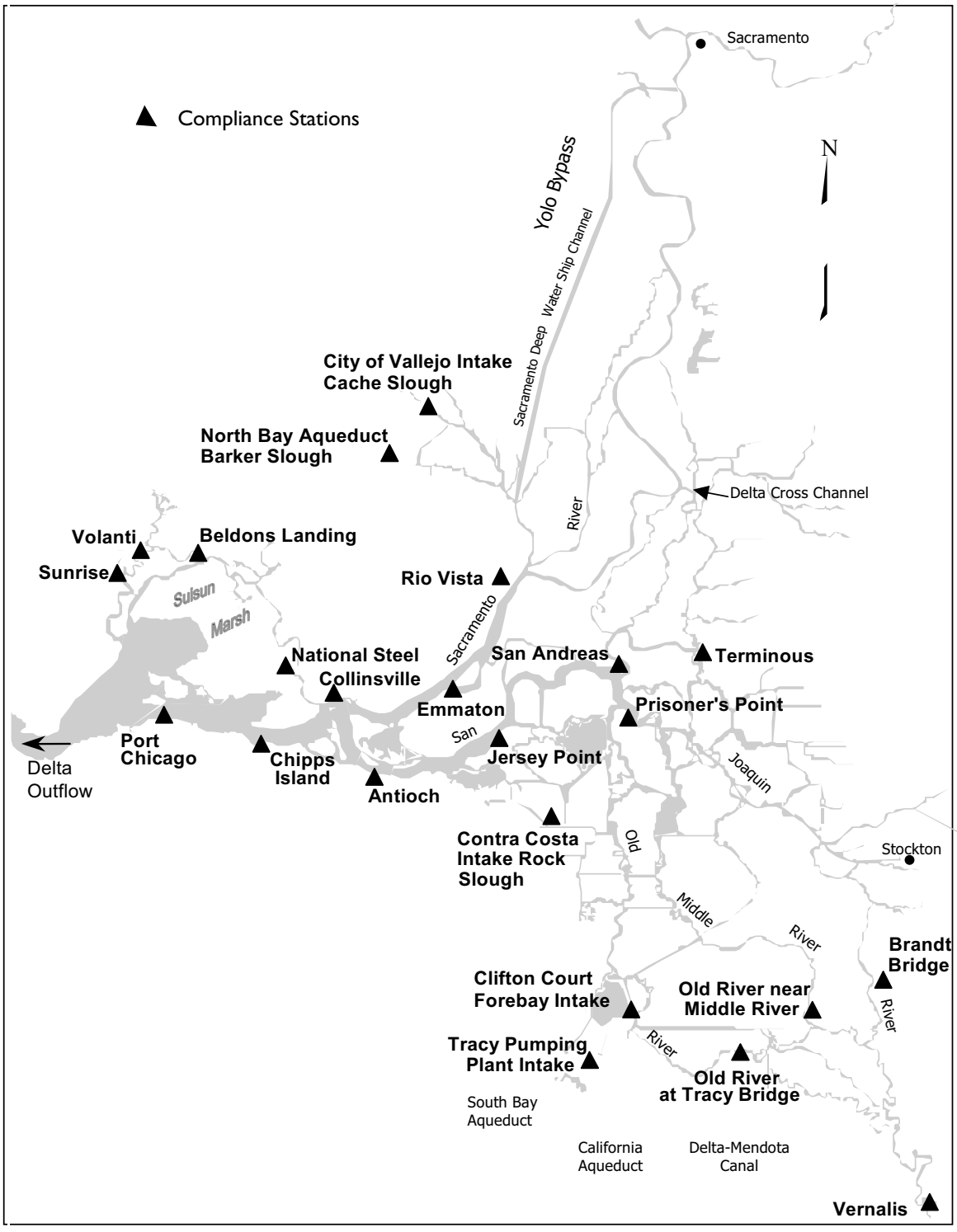


Figure 5-1. D-1641 water quality compliance locations in the Sacramento-San Joaquin Delta

Table 5-1. D-1641 Wet Year Water Quality Standards for the Sacramento-San Joaquin Delta during 2001

Compliance Location	Standard	
	Municipal and Industrial	
Contra Costa Canal Intake, Clifton Court Forebay, Tracy Pumping Plant, Contra Costa Canal Intake, Barker Slough Pumping Plant, and Cache Slough Vallejo Intake	md CL <250	All months
Contra Costa Canal Intake or Antioch Water Intake	daily CL <150	165 days in the year
	Agricultural	
Western and Interior Delta		
Emmaton and Jersey Point	14 dm EC <0.45	April 1-June 15
Emmaton	14 dm EC <1.67	June 15-August 15
Jersey Point	14 dm EC <1.35	June 15-August 15
Terminous	14 dm EC <0.45	April 1-August 15
San Andreas Landing	14 dm EC <0.45	April 1-June 25
	14 dm EC <0.58	June 25-August 15
Southern Delta		
San Joaquin River at Vernalis	30 dm EC <0.7	April-August
	30 dm EC <1.0	September-March
San Joaquin River at Brandt Bridge, Old River near Middle River, and Old River at Tracy Road Bridges	30 dm EC <1.0	April-August (until 4/1/05)
	30 dm EC <1.0	September-March
Export Area		
Clifton Court Forebay and Tracy Pumping Plant	mm EC <1.0	all months
	Fish and Wildlife	
Dissolved Oxygen[a]		
San Joaquin River between Turner Cut and Stockton	DO >6.0	September-November
San Joaquin River Salinity		
Jersey Point to Prisoner's Point	14 dm EC <0.44	April-May
Habitat Protection Salinity Starting Condition February starting salinity: - If January 8-River Index >900 taf, then the daily or 14-day running average EC at Collinsville ≤2.64 mS/cm for at least 1 day between February 1-14. - If January 8-River Index is between 650 TAF and 900 TAF, then the CALFED Operations Group will determine if this requirement must be met. See Table 5-3 for determination of compliance of 2.64 mS/cm at Chipps Island or Port Chicago.		
Suisun Marsh (see Table 5-4)		

Note: DO: dissolved oxygen (mg/L); CL: chlorides (mg/L); EC: electrical conductivity (mS/cm); md: mean daily; 30 dm: 30-day running mean; 14 dm: 14-day running mean; mm: mean monthly; 28 dm: 28-day running mean.

[a]Dissolved oxygen objective is contained in SWRCB's 1995 Bay-Delta Plan.

Municipal and Industrial Objectives

Municipal and industrial water quality objectives based on mean daily chloride values are set at several Delta export locations: Clifton Court Forebay, Tracy Pumping Plant, Contra Costa Canal at Pumping Plant #1, Barker Slough, and Cache Slough. The Clifton Court Forebay is the start of the SWP's California Aqueduct and Tracy Pumping Plant is the start of CVP's Delta-Mendota Canal. The Contra Costa Canal Intake at Rock Slough is at the start of a supply canal that conveys water to eastern Contra Costa County. Cache Slough is an intake for the City of Vallejo. The Cache Slough objective was not in effect in 2001 because water has not been withdrawn from the site in several years. A mean daily chloride objective of not more than 250 mg/L was in effect for the entire 2001 calendar year at all the other export locations. The chloride objective was met at all stations except at Contra Costa Canal Pumping Plant #1 on Rock Slough. The chloride objective was exceeded at Conta Costa Canal on October 14, 16, and 17 with measurements of 263 mg/L, 257 mg/L, and 257 mg/L respectively. It was determined that the increase in chloride was due to local agricultural drainage, as chloride measurements at nearby Delta locations were not in concurrence (Figure 5-2).

SWRCB's D-1641 contains an additional municipal and industrial objective requiring that chloride not exceed 150 mg/L for a specified number of days accrued in intervals of at least 2 weeks, at the better of two stations, either the Contra Costa Canal Pumping Plant #1 or the Antioch Water Works Intake. The percentage of days in the calendar year required by this objective is a function of water year type. It varies between 42 and 66 percent of the year, becoming less stringent under drier conditions. The dry year 165-day (45 percent of the year) criterion was met at the Contra Costa Canal Pumping Plant #1 on July 22, 2001.

Agricultural Objectives

Agricultural EC objectives are contained within D-1641 to protect Delta agriculture during the irrigation season, from April 1 to August 15. Compliance locations in the western Delta include Emmaton and Jersey Point, with San Andreas Landing and Terminous in the interior Delta. When hydrologic conditions are drier than average, the objectives are relaxed during the latter part of the irrigation season to reflect the water quality that would have occurred in the absence of the SWP and CVP. Under critical-year conditions, relaxation occurs for the entire growing season to reflect salinity intrusions expected with lower basin runoff into the Delta. The dry year agricultural water quality objective is set as a maximum 14-day running average EC of 0.45 mS/cm from April 1 through June 15 at Emmaton and Jersey Point. From June 15 to August 15 the objective rises to 1.67 mS/cm at Emmaton and 1.35 mS/cm at Jersey Point. At Terminous, the 14-day average of EC objective is 0.45 mS/cm for the entire April through August 15 period. The dry-year standard at San Andreas Landing is 0.45 mS/cm from April 1 through June 25, rising to 0.58 mS/cm from June 25 through August 15. Additional year-round compliance locations in the southern Delta are at Vernalis, Brandt Bridge, Old River near Middle River, and Old River at Tracy Road Bridge. The Vernalis agricultural objective, based on a 30-day running average, is set at 0.70 mS/cm from April-August and rises to 1.0 mS/cm September-March.

The objective at the other south Delta compliance locations (maximum monthly average) is 1.0 mS/cm year-round. On April 1, 2005, the D-1641 standard at Brandt Bridge, Old River near Middle River, and Old River at Tracy Road Bridge will change to 0.7 mS/cm from April through August and 1.0 mS/cm during the balance of the year (Figures 5-3, 5-4, and 5-5).

The responsibility for meeting standards and objectives is generally apportioned under COA to be met by the Department and the Bureau, with the exception of SWRCB San Joaquin River agricultural objectives at Vernalis and Brandt Bridge. These agricultural standards are the expressed responsibility of the Bureau, since the Department does not regulate any reservoirs upstream of the San Joaquin River. During 2001,

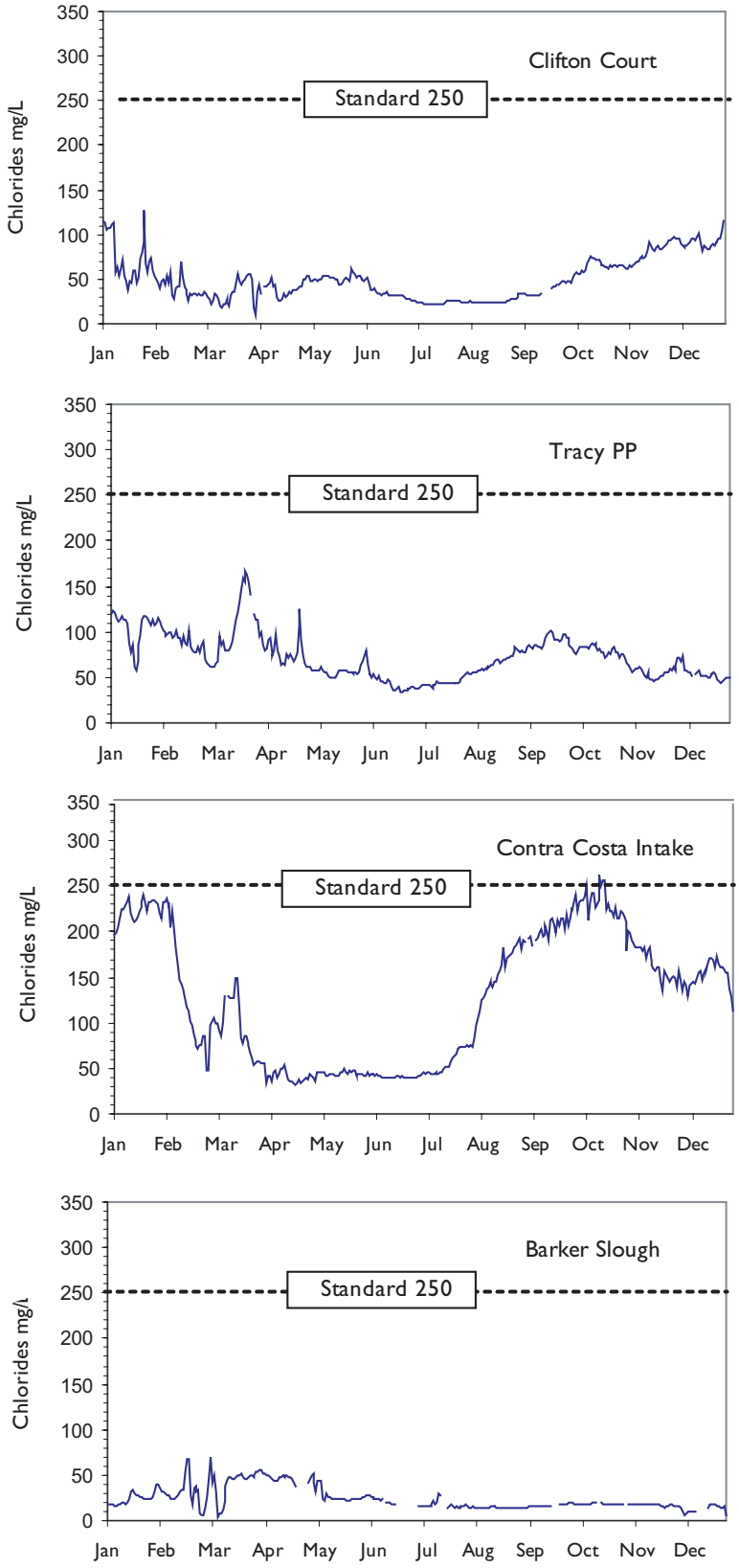


Figure 5-2. Municipal and industrial water quality objectives during 2001

the Department met all standards for which it has responsibility under COA and SWRCB. These included the Emmaton, Jersey Point, Terminous, and San Andreas Landing agricultural standards. The Department also has an obligation to maintain water quality for agricultural uses under the 1981 North Delta Water Agency contract, as amended.

Fish and Wildlife Objectives

D-1641 contains several water quality objectives for the protection of Delta fish and wildlife. These include a water quality objective for EC on the San Joaquin River measured between Jersey Point and Prisoner's Point and at several locations in the Suisun Marsh. Suisun Marsh standards are discussed below in the Suisun Marsh Protection Plan and Preservation Agreement section. Other objectives combining both EC and flow were set to protect the estuarine habitat in the Suisun Bay area. The San Joaquin River dissolved oxygen objective was carried over from D-1422 to the 1995 Bay-Delta Plan. All of these measures were established in part to encourage spawning and survival of striped bass and to protect migrating salmon.

San Joaquin River Salinity Objective

The Jersey Point and Prisoner's Point standard is set as a maximum 14-day running mean of

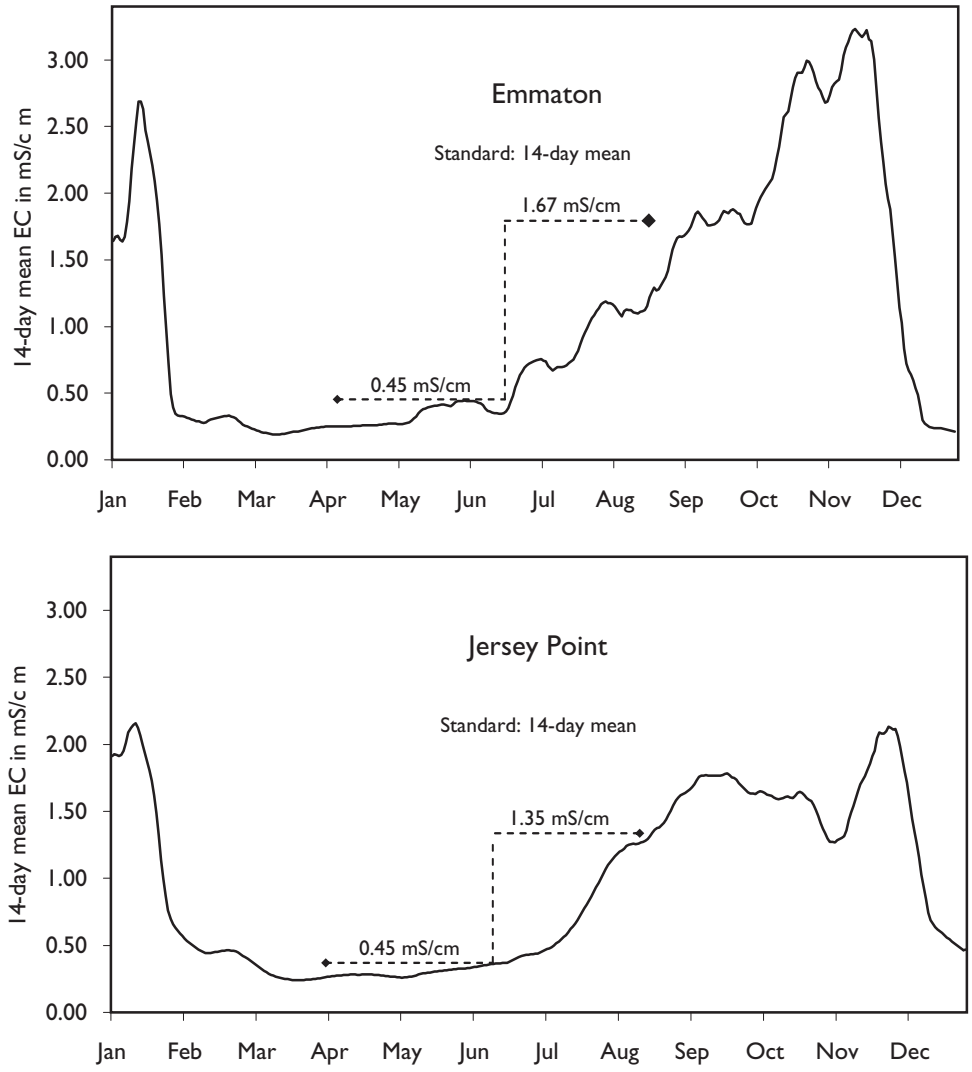


Figure 5-3. Agricultural water quality objectives in the western Delta during 2001

0.44 mS/cm during April and May to protect striped bass spawning habitat. Compliance with the Prisoner's Point EC objective is actually measured at San Andreas Landing, which provides a conservative estimate due to its location west of Prisoner's Point. Jersey Point values averaged 0.29 mS/cm and never exceeded 0.36 mS/cm during the April 1 through May 31 compliance period. EC at San Andreas Landing averaged 0.24 mS/cm for the period and never exceeded 0.29 mS/cm.

Dissolved Oxygen Objective

The 1995 Bay-Delta Plan includes a dissolved oxygen objective to protect fall-run salmon migration in the lower San Joaquin River similar to, but more stringent than, the DO standard in D-1422. DO levels are required to be at least 6.0 mg/L during September through November. During late summer and early fall each year, DO concentrations in the Stockton Ship Channel are closely monitored because they can deteriorate to critically low levels (<5.0 mg/L). DO is measured at 14 sites, at the water surface and at the channel bottom, between Prisoner's Point and the Stockton Deep Water Channel Turning Basin.

Low oxygen conditions may result from many factors — low stream inflows, intermittent

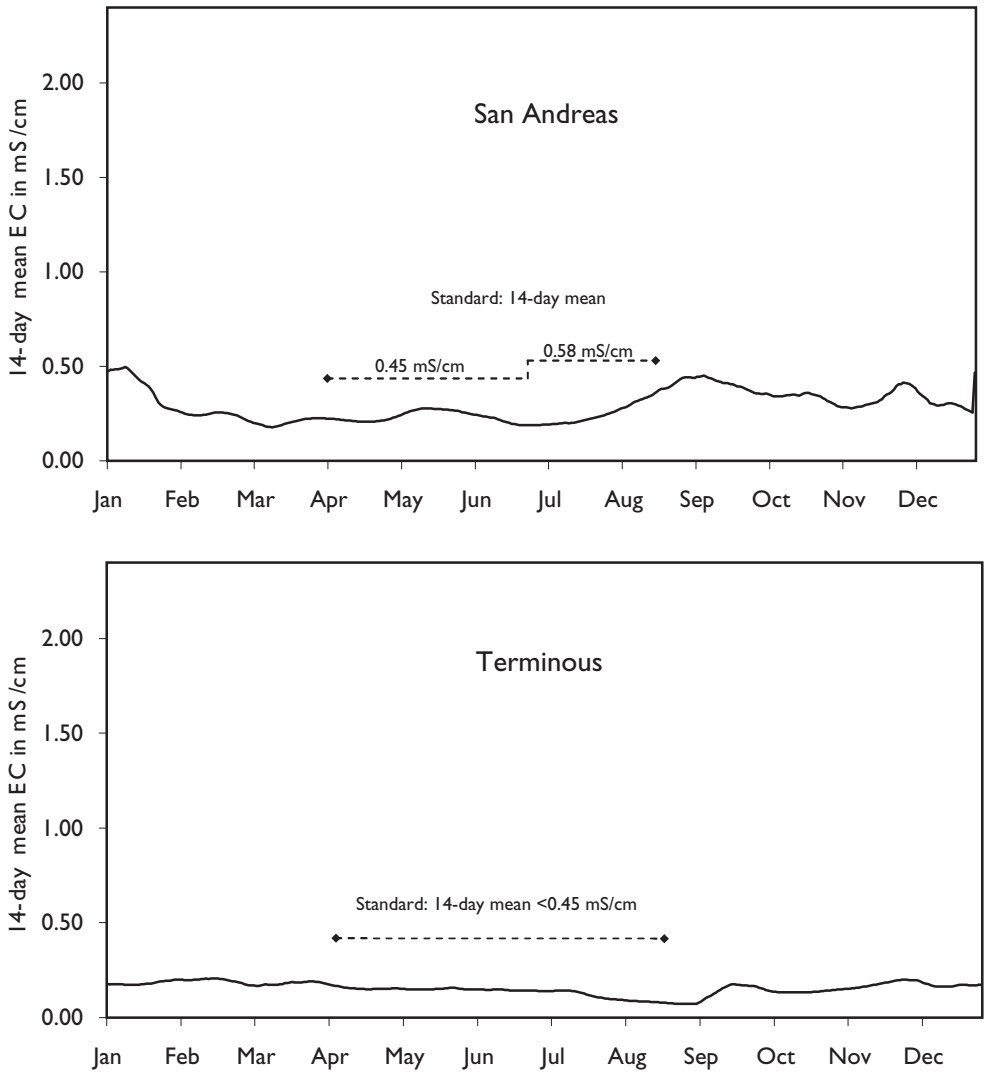


Figure 5-4. Agricultural water quality objectives in the interior Delta during 2001

reverse-flow conditions in the San Joaquin River past Stockton, warm water temperatures, reduced tidal mixing, and high biochemical oxygen demand levels as the result of regulated discharges in the Stockton area and recreational activity adjacent to the basin. The Department's Operation Control Office monitors DO in the Stockton Ship Channel as the basis for some operational decisions. The fall installation of the Old River at Head barrier is a commonly used remedy for low DO conditions in the lower San Joaquin River. The barrier increases net flows down the San Joaquin River past Stockton, helping to improve dissolved oxygen levels, particularly in the eastern channel.

Water year 2001 for the San Joaquin Valley was classified as *dry* and the fall season Old River at Head barrier was installed on October 6, 2001, to help boost low San Joaquin River flows at Vernalis and projected fall flows which would be insufficient to maintain minimum DO standards in the eastern channel. Average daily flows in the San Joaquin River past Stockton ranged from -366 cfs to +796 cfs during August through October 2001.

DO in the western portion of the channel from Prisoner's Point to Disappointment Slough remained relatively high and stable throughout the study period, ranging from 7.2 to 9.9 mg/L (Figure 5-6).

This is typical of most years in the western channel where tidal mixing and the lack of conditions favorable to the creation of high biochemical oxygen demand allow DO to maintain relatively high levels.

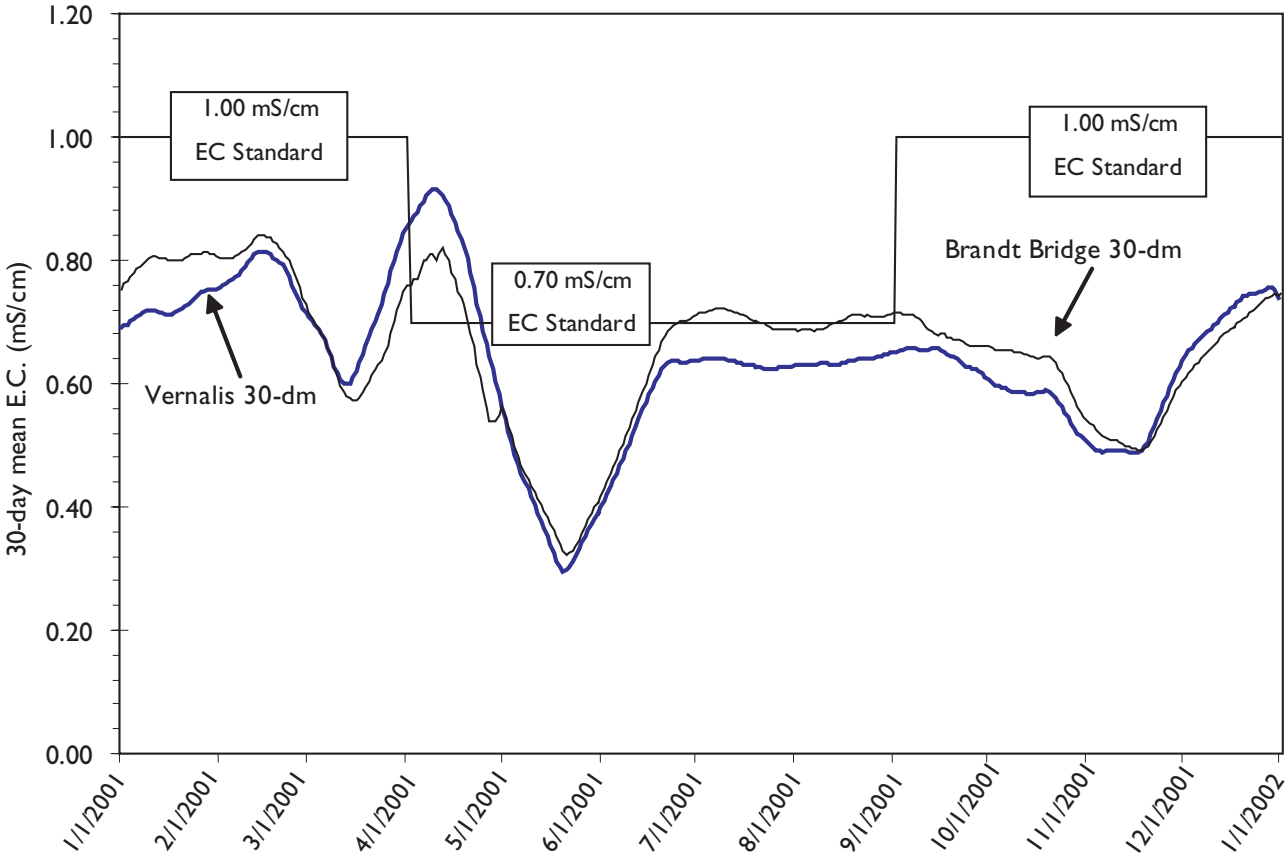


Figure 5-5. San Joaquin River EC standards during 2001. The 30-day running average resets on April 1 and September 1 to allow for the change. SWRCB allows 30-day average on April 30 to apply for entire month of compliance. EC standard at Brandt Bridge will be required to meet the 0.70 mS/cm standard on April 1, 2005. Until that time the year-round standard will be 1.0 mS/cm.

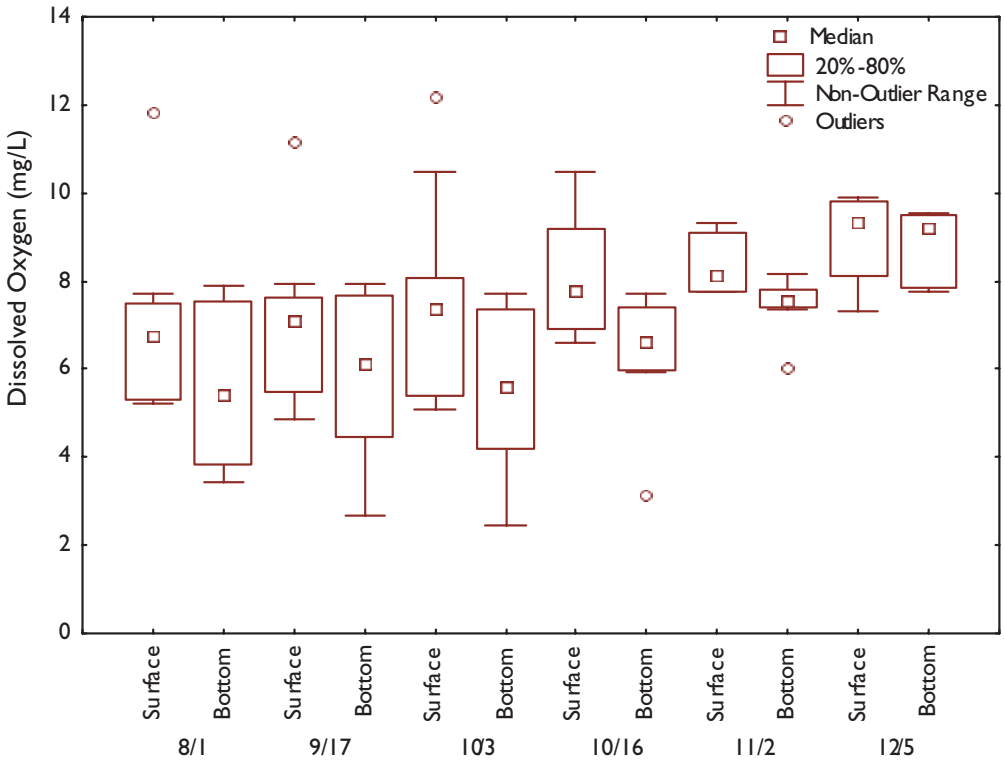


Figure 5-6. Dissolved oxygen concentration in the Stockton Ship Channel during 2001

DO levels fell below 5.0 mg/L in the eastern portion of the channel between Turner Cut and Rough and Ready Island on August 1 and persisted until October 3. This DO decrease coincided with about a 2 mg/L decrease in DO across the region, indicating that the water column was not experiencing complete mixing or an increase in BOD at or near the bottom of the channel.

During September, DO levels of less than 6.0 mg/L occurred in the channel from Rough and Ready Island to Fourteen Mile Slough. The minimum value of 4.0 mg/L was measured at Turner Cut. This reduction in DO was due, in part, to warm water temperatures which ranged from 21 to 27 degrees Celsius and reverse flows past Stockton.

After the installation of the Old River at Head barrier on October 6, DO conditions within the channel improved significantly by October 16 as DO concentrations rose to 6.0 mg/L or above throughout the channel. Increasingly cooler water temperatures, coupled with the reduction of reverse flows past Stockton, played a part in the improvement. Monitoring on November 14, 2001, confirmed continued DO levels of 7.0 mg/L or above throughout the channel. This sustained improvement negated the need for any further monitoring and the Old River barrier was removed on December 2.

Estuarine Habitat Protection Standard (X2)

D-1641 includes an estuarine habitat protection standard that incorporates a modified X2 criteria (geographic isohaline), first established in the 1994 Delta Smelt Biological Opinion. Delta outflow is used to maintain the position of 2-ppt isohaline (2 parts per thousand of salt in the water), measured as 2.64 mS/cm on the water's surface at either Chipps Island or Port Chicago during February through June. This required location of the isohaline is associated with fish and biota abundance.

The number of days per month when the daily averaged EC maximum (2.64 mS/cm) is in effect at Chipps Island or, under specific conditions, at Port Chicago, is conditioned by the previous month's Eight River Index (PMI) and is noted in Table 4 of D-1641 (Table 5-2). The Port Chicago standard is usually in effect during months when the Port Chicago 14-day EC average immediately prior to the first day of the month is less than or equal to 2.64 mS/cm. If salinity or flow requirements are met for a greater number of days than required for any month, the excess days are applied to meeting the requirements for the following month.

Department Environmental Scientist prepares to measure and release white sturgeon caught in a fyke trap as part of the Yolo Bypass Study.

The daily averaged EC for X2 may be alternately met with a 14-day running average of EC for the two locations, or a flow alternative set as a 3-day running average of NDOI for the required number of days. The NDOI requirement is set at 11,400 cfs or 29,200 cfs when the X2 is located at Chipps Island or Port Chicago, respectively. During 2001, the PMI for February through June was 0.86 maf, 1.5 maf, 2.39 maf, 2.03 maf, and 2.49 maf, respectively. Using Table 4 in D-1641, the number of days of compliance maintaining a maximum EC of 2.64 mS/cm at Chipps Island was 11 days for February. During March, April, and May, compliance was also required at Chipps Island for 31 days, 28 days, and 1 day, respectively. During June, X2 was met at Collinsville, which is the default location used when PMI corresponds to 0 days at Chipps Island. X2 compliance at Collinsville was required and met for all 30 days of June.

The X2 Habitat Protection standard at Chipps Island during February was met with the required accumulated number of days of 3-day mean of NDOI greater than 11,400 cfs and days with EC below 2.64 mS/cm. From March through May, the Chipps Island X2 standard was met using accumulated days of NDOI flows above 11,400 cfs and days with EC below 2.64 mS/cm. June's requirement of 30 days at Collinsville was met with a 14-day running average of below 2.64 mS/cm (Table 5-3).

Suisun Marsh Water Quality

The Suisun Marsh, located in southern Solano County, provides one of the largest estuarine waterfowl habitats in the continental United States and represents more than 10 percent of California's remaining natural wetland habitat. The marsh also provides resting and feeding grounds for thousands of waterfowl migrating on the Pacific Flyway.

Suisun Marsh water quality has been protected since 1971, first through SWRCB's D-1379 and later in 1978 by D-1485. In 1987, the Department signed the Suisun Marsh Preservation Agreement in conjunction with the Bureau, DFG, and the Suisun Resources Conservation District, which represents private landowners.

Table 5-2. D-1641 Table 4: Habitat Protection Outflow

Chipps Island					
PMI (taf)	*Feb*	*Mar*	*Apr*	*May*	*Jun*
500	0	0	0	0	0
750	0	0	0	0	0
1,000	28[a]	12	2	0	0
1,250	28	31	6	0	0
1,500	28	31	13	0	0
1,750	28	31	20	0	0
2,000	28	31	25	1	0
2,250	28	31	27	3	0
2,500	28	31	29	11	1
2,750	28	31	29	20	2
3,000	28	31	30	27	4
3,250	28	31	30	29	8
3,500	28	31	30	30	13
3,750	28	31	30	31	18
4,000	28	31	30	31	23
4,250	28	31	30	31	25
4,500	28	31	30	31	27
4,750	28	31	30	31	28
5,000	28	31	30	31	29
5,250	28	31	30	31	29
5,500	28	31	30	31	30

Port Chicago					
PMI (taf)	*Feb*	*Mar*	*Apr*	*May*	*Jun*
0	0	0	0	0	0
250	1	0	0	0	0
500	4	1	0	0	0
750	8	2	0	0	0
1,000	12	4	0	0	0
1,250	15	6	1	0	0
1,500	18	9	1	0	0
1,750	20	12	2	0	0
2,000	21	15	4	0	0
2,250	22	17	5	1	0
2,500	23	19	8	1	0
2,750	24	21	10	2	0
3,000	25	23	12	4	0
3,250	25	24	14	6	0
3,500	25	25	16	9	0
3,750	26	26	18	12	0
4,000	26	27	20	15	0
4,250	26	27	21	18	1
4,500	26	28	23	21	2
4,750	27	28	24	23	3
5,000	27	28	25	25	4
5,250	27	29	25	26	6
5,500	27	29	26	28	9
5,750	27	29	27	28	13
6,000	27	29	27	29	16
6,250	27	30	27	29	19
6,500	27	30	28	30	22
6,750	27	30	28	30	24
7,000	27	30	28	30	26
7,250	27	30	28	30	27
7,500	27	30	29	30	28
7,750	27	30	29	31	28
8,000	27	30	29	31	29
8,250	28	30	29	31	29
8,500	28	30	29	31	29
8,750	28	30	29	31	30
9,000	28	30	29	31	30
9,250	28	30	29	31	30
9,500	28	31	29	31	30
9,750	28	31	29	31	30
10,000	28	31	30	31	30
10,000	28	31	30	31	30

[a]When 800 taf <PMI.

Note: Number of days when maximum daily average EC 2.64 mS/cm must be maintained. (This can also be met with maximum 14-day running average EC of 2.64 mS/cm, or 3-day running average Delta outflows of 11,400 cfs and 29,200 cfs, respectively.) Port Chicago standard is triggered only when the 14-day average EC for the last day of the previous month is 2.64 mS/cm or less. PMI is previous month's 8-RI. If salinity/flow objectives are met for a greater number of days than required for any month, the excess days shall be applied towards the following month's requirement. The number of days or values of the PMI between those specified below shall be determined by linear interpolation.

Table 5-3. Determination of Habitat Protection Compliance during 2001

		Compliance					
Month	**PMI[a]**	*Location*	*Required Days*	**Days Met**	**Carryover Days[b]**	**Criteria Used to Meet Objective[c]**	**Criteria for Meeting Standard (days met)**
Feb	0.86	Chipps Island	11	19	8	3-dm of NDOI >11,400cfs daily mean of EC 14-day mean of EC	19 11 13
Mar	1.50	Chipps Island	31	31	0	3-dm of NDOI >29,200 cfs daily mean of EC 14-day mean of EC	22 31 31
Apr	2.39	Chipps Island	28	30	2	3-dm of NDOI >29,200 cfs daily mean of EC 14-day mean of EC	15 21 22
May	2.03	Chipps Island	1	7	6	3-dm of NDOI >29,200 cfs daily mean of EC 14-day mean of EC	7 3 3
Jun	2.49	Collinsville	30	30	0	3-dm of NDOI >11,400 cfs daily mean of EC 14-day mean of EC	25 25 30

Note: Shaded area describes which criteria were used to meet compliance days and how many days of each were met.

[a]PMI - Previous month's Eight River Index in maf.

[b]Carryover days may be used to meet the next month's requirement, if at the same compliance location.

[c]Compliance may be met using either daily EC, 14-dm EC <2.64 mS/cm or specific 3-dm of NDOI.

In 1995, SWRCB WR 95-06 eliminated the Chipps Island running 28-day salinity average standard and the Eastern Marsh standard at Mallard. WR 95-06 added a new narrative objective for the brackish tidal marshes of Suisun Bay to protect remnant tidal marshes and changed the compliance date for two western Suisun Marsh stations, S-35 and S-97, to October 1997. SWRCB granted extensions three times, pushing the compliance requirement to November 1, 1999. D-1641 converted these two western marsh stations to monitoring stations, dropping the compliance requirements at both locations.

The Suisun Marsh Salinity Control Gates began operating in 1989 on an as-needed basis during the control season (from October 1 to May 31) and are operated to meet D-1641 salinity standards. The gates, located 2 miles downstream from Collinsville in Montezuma Slough, respond to daily tidal fluctuations, opening to admit fresher flow from the Sacramento River and closing to block tidal saltwater intrusion from Suisun Bay. The gates are considered to be in full operation when all three gates are tidally operated, the flashboards have closed off the channel, and the boat lock is operational.

During the thirteenth control season (October 1, 2000, through May 31, 2001), the fall 2000 fish passage study was postponed to allow time for further review of past results. As a result, the gates were operated primarily for salinity control. The gates were held open with flashboards removed from October 1 to November 3, 2000, due to good water quality conditions in the marsh. Salinity began increasing during the latter part of October; consequently, the flashboards were installed and the gates were placed into operation on November 4 and continued through mid-May to control salinity levels. From May 14, 2001, through the balance of the control season, gate operations ceased and the

flashboards were removed as salinity levels improved.

All Suisun Marsh salinity standards were met during 2001 (Table 5-4).

Bay-Delta Plan Brackish Tidal Marshes of Suisun Bay Narrative

The Bay-Delta Plan's narrative water quality objective for brackish tidal marsh protection is stated as:

> Water quality sufficient to support a natural gradient on species composition and wildlife habitat characteristic of a brackish marsh throughout all elevations of the tidal marshes bordering Suisun Bay shall bemaintained. Water quality conditions shall be maintained so that none of the following occurs: (a) loss of diversity; (b) conversion of brackish marsh to salt marsh; (c) for animals, decreased population abundance of those species vulnerable to increased mortality and loss of habitat from increased water salinity; or (d) for plants, significant reduction in stature or percent cover from increased water or soil salinity or other water quality parameters.

SWRCB determined that implementation of Bay-Delta Plan numerical objectives, particularly NDOI, would achieve the narrative objective. In the future, the Department and the Bureau will review and replace the narrative objective with Suisun Marsh Ecological Workgroup recommendations. SEW completed its final report in 2001 and it will be submitted to the SWRCB sometime in 2002.

Table 5-4. D-1641 Suisun Marsh Salinity Standards in Effect during 2001

Month	Standard MHTEC[a]	Actual MHTEC				
		C-2 Collinsville	*S-64 National Steel*	*S-49 Beldons Landing*	*S-42 Volanti*	*S-21 Sunrise Club*
			Thirteenth Control Season			
January	12.5	6.3	5.4	6.8	9.1	9.1
February	8.0	NA[a]	1.7	2.3	3.8	3.8
March	8.0	0.4	0.4	0.7	1.4	1.4
April	11.0	1.3	0.9	1.1	1.7	1.8
May	11.0	3.4	3.0	4.6	5.4	6.2
			Fourteenth Control Season			
October	19.0	11.8	12.0	16.1	17.5	17.5
November	15.5	11.2	8.9	10.4	12.9	12.8
December	15.5	1.5[b]	1.4	2.8	2.9[c]	3.9

Note: Additional stations S-35 and S-97 converted to monitoring stations with the adoption of D-1641.

[a]MHTEC - Monthly average of both daily high-tide ECs in mS/cm.

[b]No data available due to telemetry problem.

[c]Values do not reflect end of month means due to equipment failure during the month.

Western Delta Municipal and Industrial Users Agreements

Several contracted water quality standards are in effect for western Delta municipal and industrial water users that predate D-1485 and subsequent water rights decisions and plans. Under agreements with both municipal and industrial contractors, loss of offshore water is compensated for by substitute water supplies, net credit balances for days of above-average water, or monetary payment.

The Department contracted with the Contra Costa Water District in 1967 and with the City of Antioch in 1968 to ensure that the water district and the city would be compensated for costs associated with the loss of usable offshore Delta water supplies resulting from SWP operations. Credit for the number of days of above-average offshore water supplies of sufficient quality is accrued to offset the number of below-average days in future years. Contra Costa's standard is for 142 days and Antioch's is 208 days of usable water. During water year 2001, a usable Delta water supply was available to Contra Costa and City of Antioch throughout the period of standard and no compensation payments were necessary.

The skyline of Sacramento as viewed from the Yolo Bypass

Conversion Factors

Quantity	To convert from customary unit	To metric unit	Multiply customary unit by	To convert to customary unit, multiply metric unit by
Length	inches (in)	millimeters (mm)●	25.4	0.03937
	inches (in)	centimeters (cm)	2.54	0.3937
	feet (ft)	meters (m)	0.3048	3.2808
	miles (mi)	kilometers (km)	1.6093	0.62139
Area	square inches (in^2)	square millimeters (mm^2)	645.16	0.00155
	square feet (ft^2)	square meters (m^2)	0.092903	10.764
	acres (ac)	hectares (ha)	0.40469	2.4710
	square miles (mi^2)	square kilometers (km^2)	2.590	0.3861
Volume	gallons (gal)	liters (L)	3.7854	0.26417
	million gallons (10^6 gal)	megaliters (ML)	3.7854	0.26417
	cubic feet (ft^3)	cubic meters (m^3)	0.028317	35.315
	cubic yards (yd^3)	cubic meters (m^3)	0.76455	1.308
	acre-feet (ac-ft)	thousand cubic meters ($m^3 \times 10^3$)	1.2335	0.8107
	acre-feet (ac-ft)	hectare-meters (ha - m)■	0.1234	8.107
	thousand acre-feet (taf)	million cubic meters ($m^3 \times 10^6$)	1.2335	0.8107
	thousand acre-feet (taf)	hectare-meters (ha - m)■	123.35	0.008107
	million acre-feet (maf)	billion cubic meters ($m^3 \times 10^9$)◆	1.2335	0.8107
	million acre-feet (maf)	cubic kilometers (km^3)	1.2335	0.8107
Flow	cubic feet per second (ft^3/s)	cubic meters per second (m^3/s)	0.028317	35.315
	gallons per minute (gal/min)	liters per minute (L/min)	3.7854	0.26417
	gallons per day (gal/day)	liters per day (L/day)	3.7854	0.26417
	million gallons per day (mgd)	megaliters per day (ML/day)	3.7854	0.26417
	acre-feet per day (ac-ft/day)	thousand cubic meters per day ($m^3 \times 10^3$/day)	1.2335	0.8107
Mass	pounds (lb)	kilograms (kg)	0.45359	2.2046
	tons (short, 2,000 lb)	megagrams (Mg)	0.90718	1.1023
Velocity	feet per second (ft/s)	meters per second (m/s)	0.3048	3.2808
Power	horsepower (hp)	kilowatts (kW)	0.746	1.3405
Pressure	pounds per square inch (psi)	kilopascals (kPa)	6.8948	0.14505
	head of water in feet	kilopascals (kPa)	2.989	0.33456
Specific capacity	gallons per minute per foot of drawdown	liters per minute per meter of drawdown	12.419	0.08052
Concentration	parts per million (ppm)	milligrams per liter (mg/L)	1.0	1.0
Electrical conductivity	micromhos per centimeter	microsiemens per centimeter (µS/cm)	1.0	1.0
Temperature	degrees Fahrenheit (˚F)	degrees Celsius (˚C)	(˚F - 32)/1.8	(1.8 x ˚C) + 32

● When using "dual units," inches are normally converted to millimeters (rather than centimeters).

■ Not used often in metric countries, but is offered as a conceptual equivalent of customary western U.S. practice (a standard depth of water over a given area of land).

◆ ASTM Manual E380 discourages the use of billion cubic meters since that magnitude is represented by giga (a thousand million) in other countries. It is shown here for potential use for quantifying large reservoir volumes (similar to million acre-feet).

Other Common Conversion Factors

1 cubic foot=7.48 gallons=62.4 pounds of water

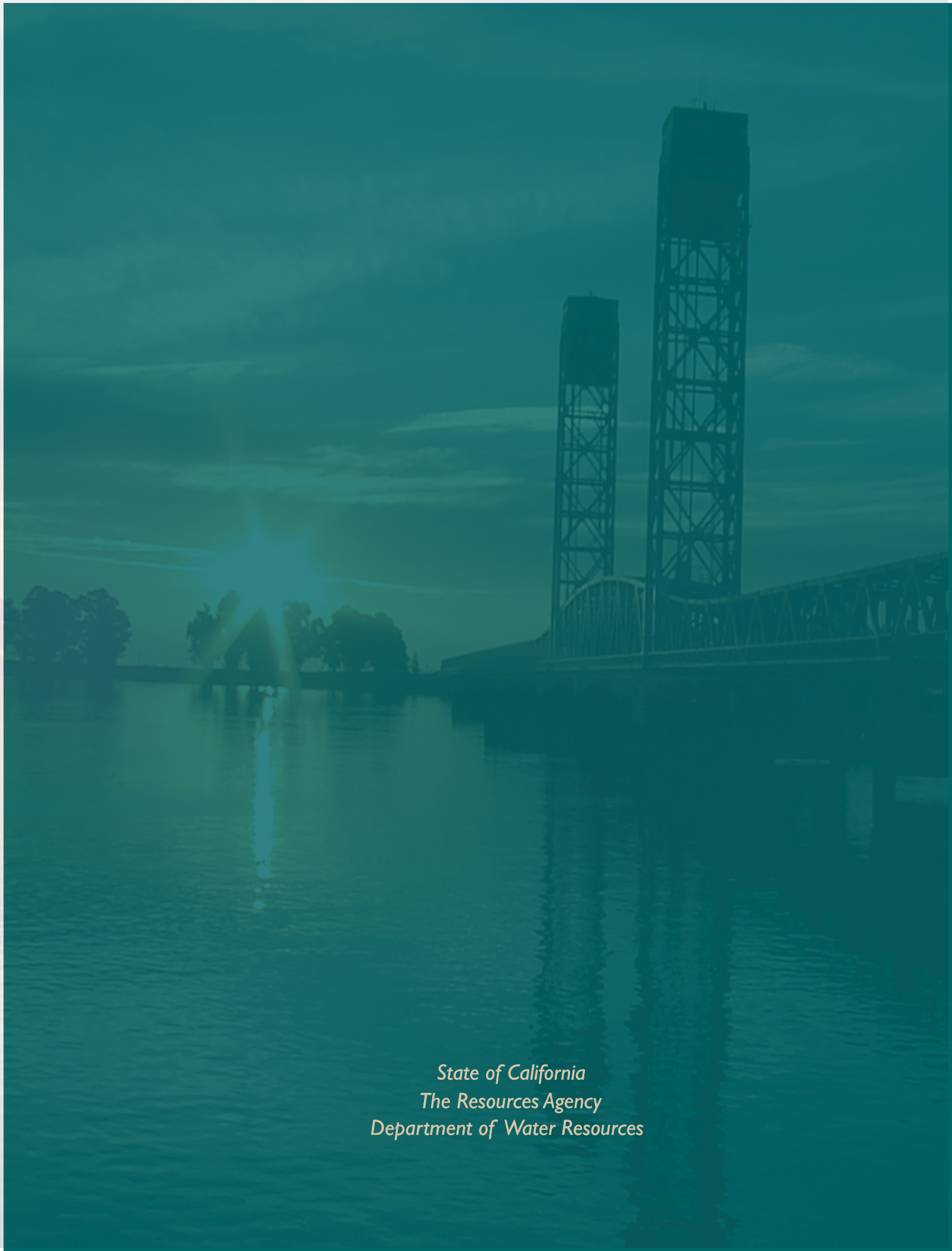
1 cubic foot per second (cfs)=450 gallons per minute (gpm)

1 cfs=646,320 gallons a day=1.98 ac-ft a day

1 acre-foot=325,900 gallons=43,560 cubic feet

1 million gallons=3.07 acre-feet

1 million gallons a day (mgd)=1,120 ac-ft a year



State of California
The Resources Agency
Department of Water Resources